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(54) **SYSTEMS AND METHODS FOR OPTIMIZING ONE OR MORE AUDIO TRACKS TO A VIDEO STREAM**

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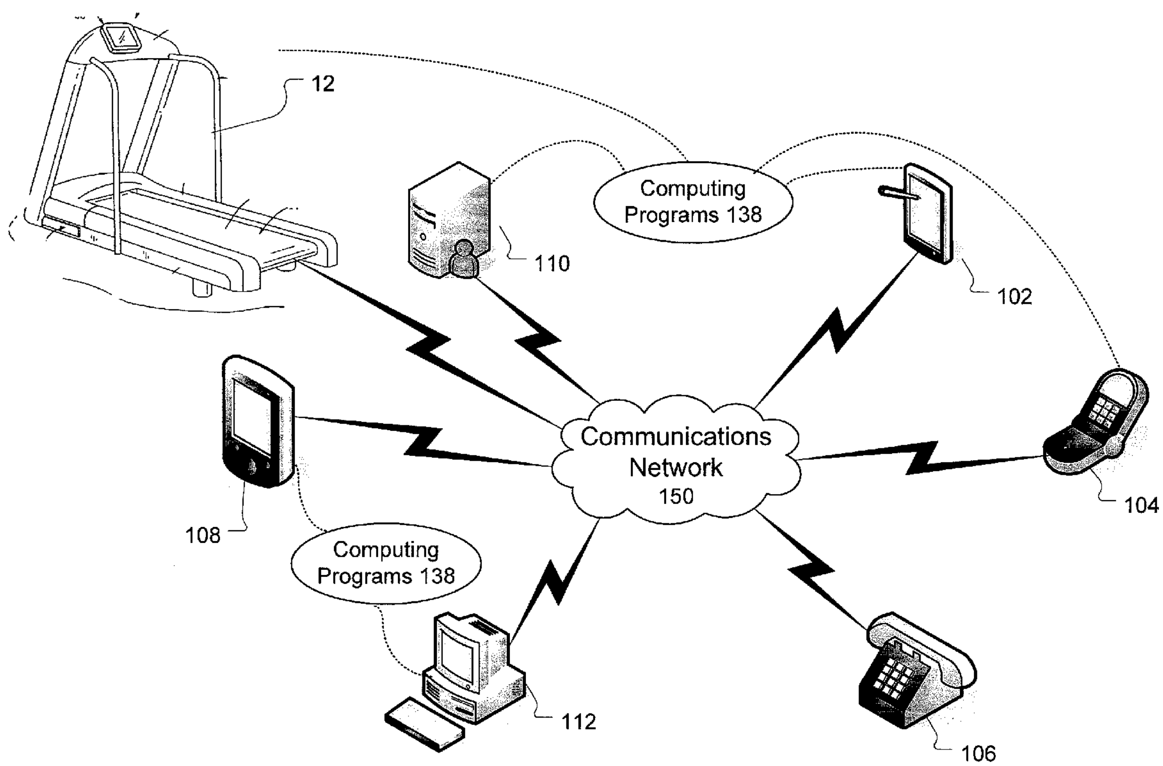
(57) **ABSTRACT**

Disclosed are systems and methods for detecting the movements in an exerciser's repetitive movement pattern that, when pre-recorded audio footfall sound files are played, most closely support the illusion that the user is generating the sounds with their own "virtual" footfalls, thus creating an enhanced virtual exercise experience. The system generates a signal to communicate the virtual footfall timing with a media playback system, and plays back media files that support the virtual exercise experience.



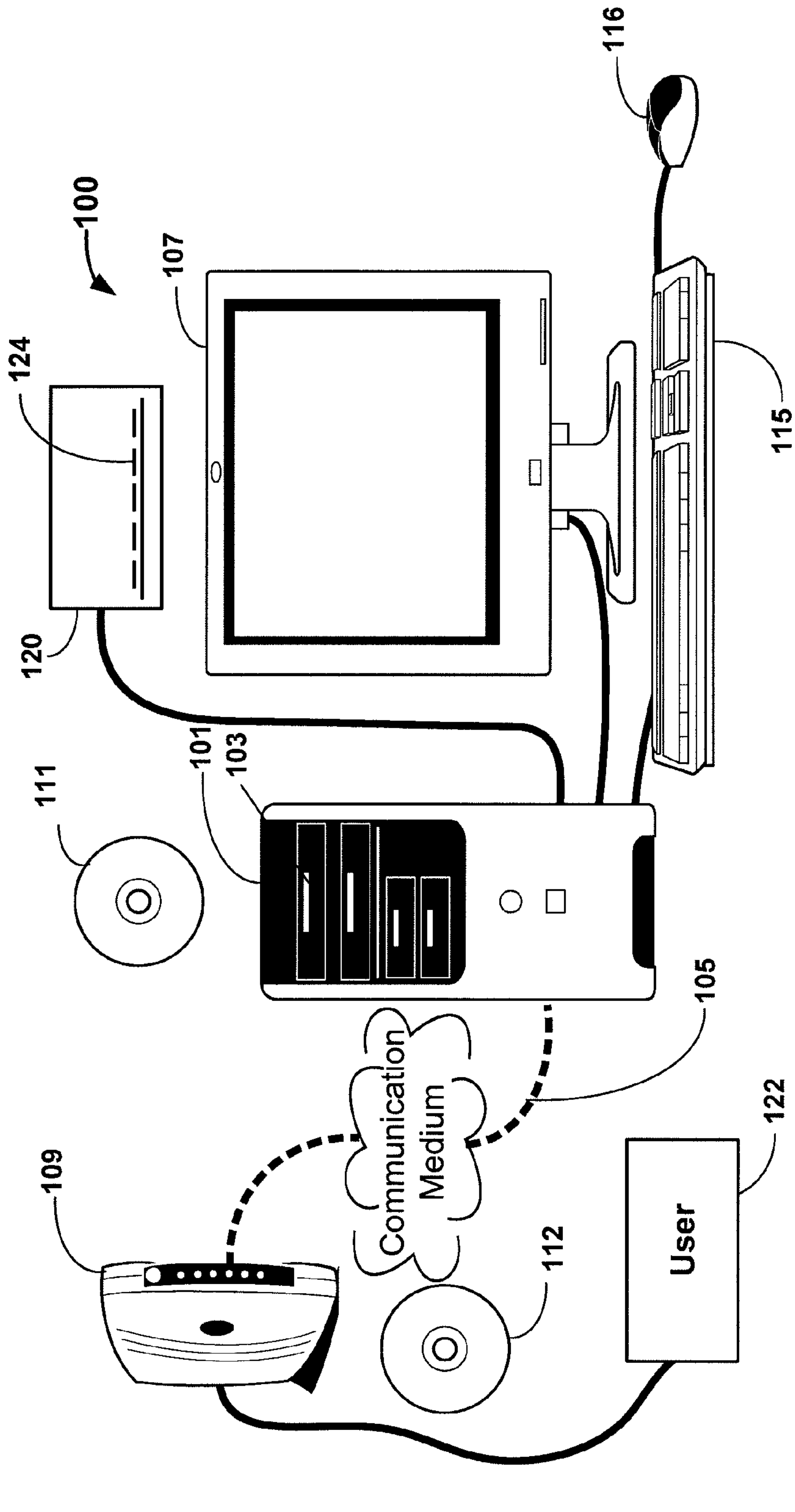

100
107
124
116
120
101
103
111
115
105
109
Communication Medium
122
User
112

Fig. 1a

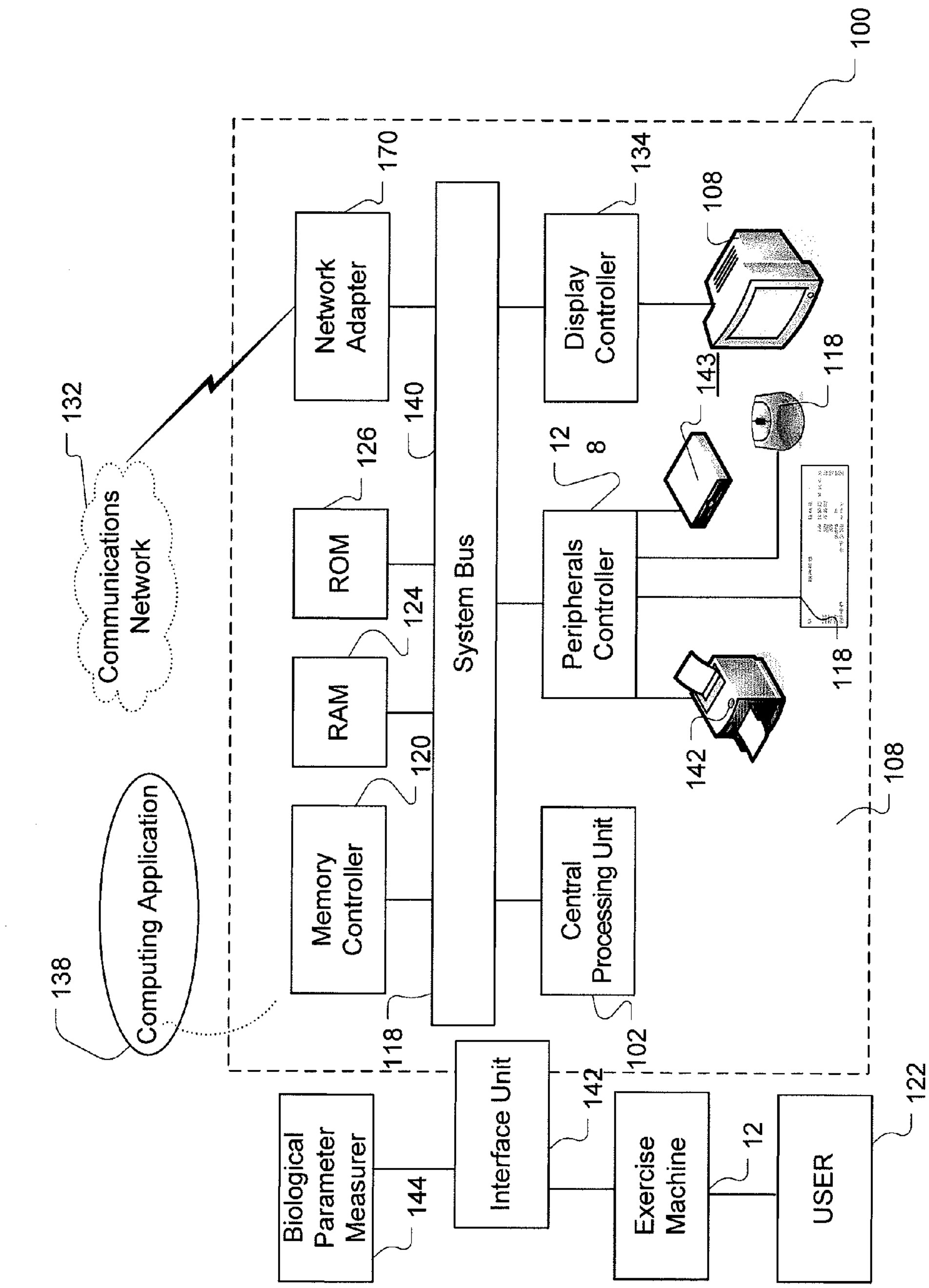

100
Communications Network
132
Computing Application
138
Network Adapter
170
ROM
126
RAM
124
Memory Controller
120
System Bus
140
118
Display Controller
134
108
143
118
Peripherals Controller
12
8
142
118
108
Central Processing Unit
102
Interface Unit
142
Biological Parameter Measurer
144
Exercise Machine
12
USER
122

Fig. 1b

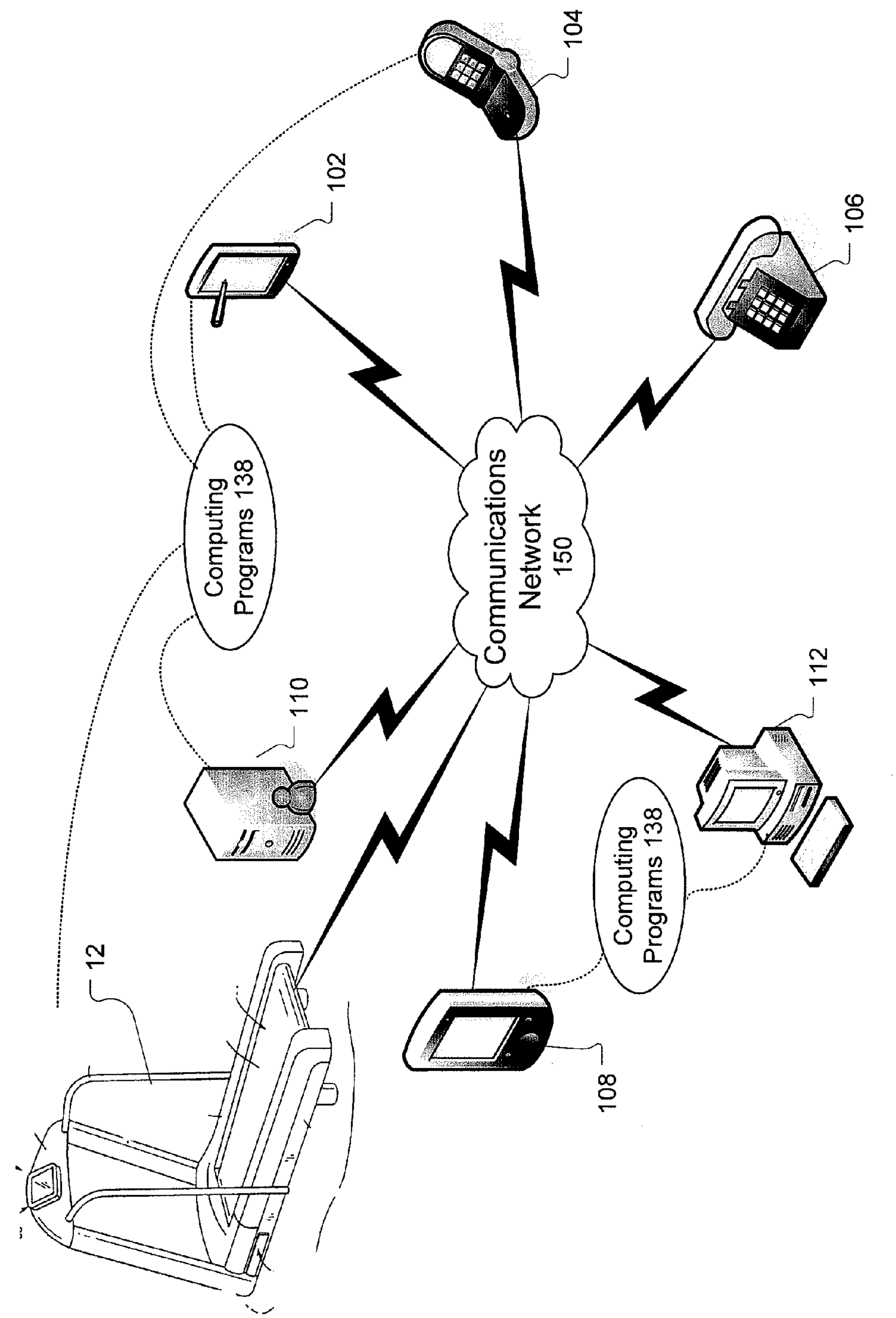

104
102
106
Computing Programs 138
Communications Network 150
110
112
12
Computing Programs 138
108

Fig. 1c

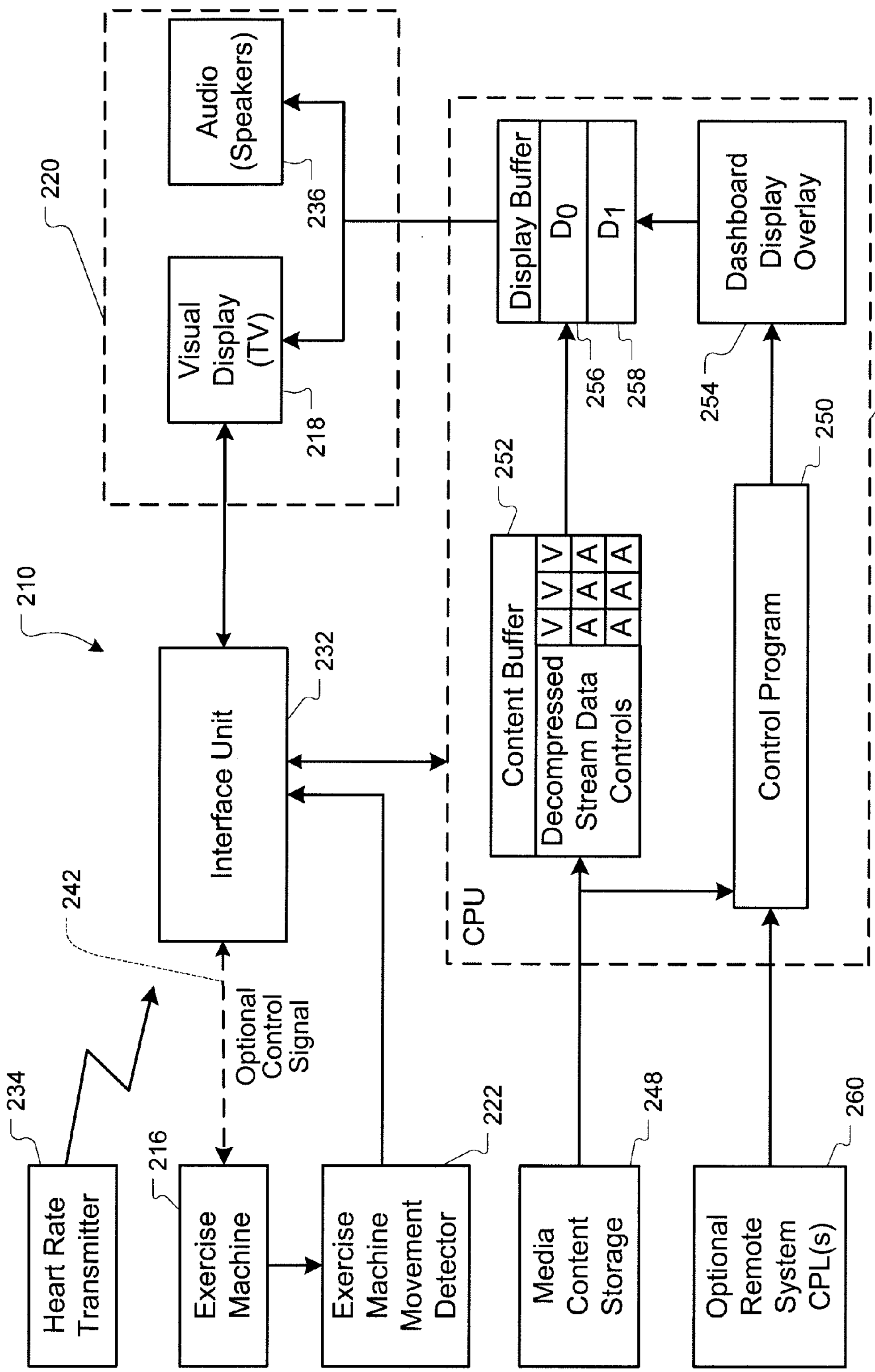

210
220
Audio (Speakers)
236
Visual Display (TV)
218
Interface Unit
232
Heart Rate Transmitter
234
Exercise Machine
216
Optional Control Signal
242
Exercise Machine Movement Detector
222
Media Content Storage
248
Optional Remote System CPL(s)
260
CPU
202
Display Buffer
D0
D1
256
258
Dashboard Display Overlay
254
Content Buffer
Decompressed Stream Data Controls
V V V
A A A
A A A
252
Control Program
250

Fig. 2

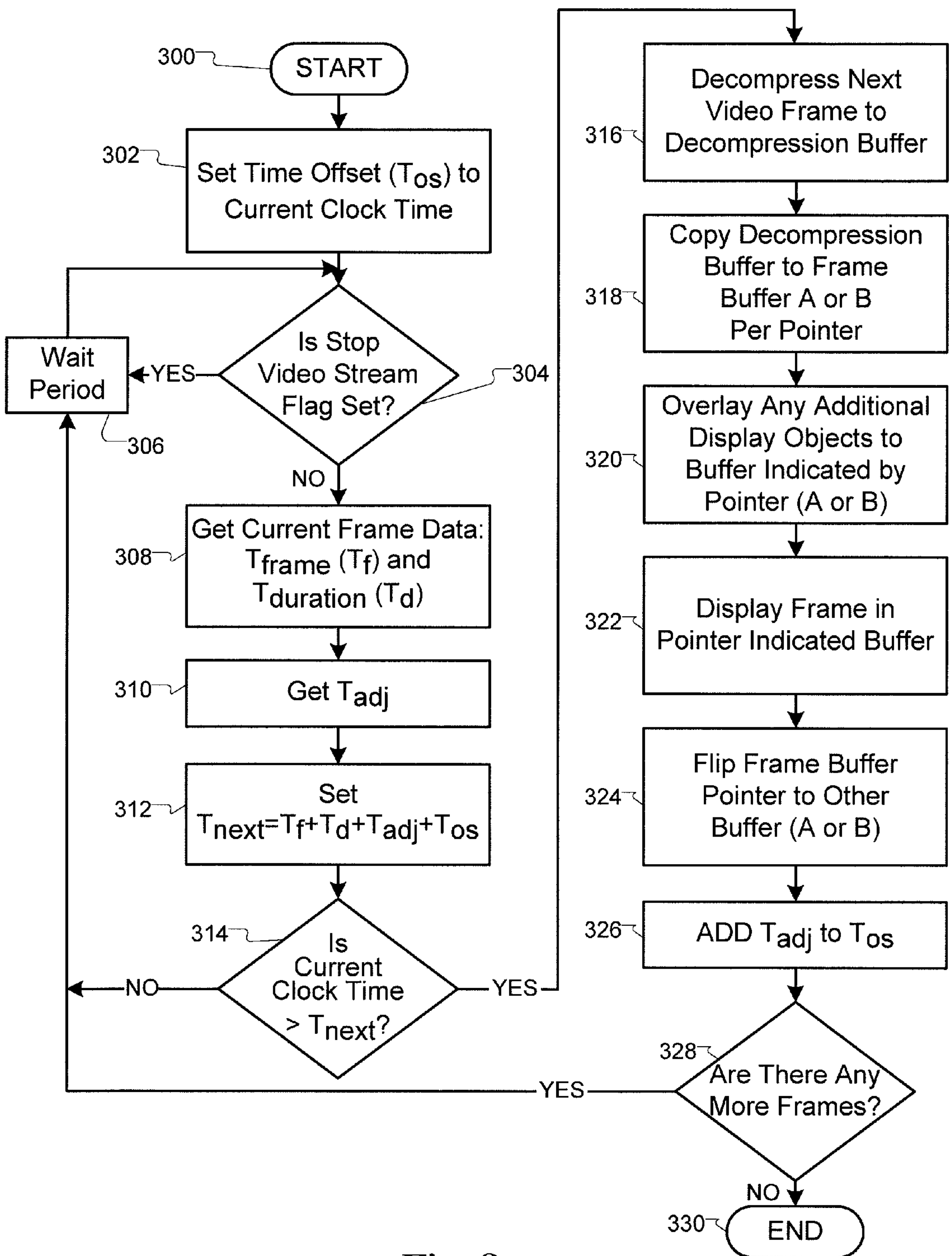

300
START
302
Set Time Offset (T_{os}) to Current Clock Time
Wait Period
YES
Is Stop Video Stream Flag Set?
304
306
NO
308
Get Current Frame Data: T_{frame} (T_f) and $T_{duration}$ (T_d)
310
Get T_{adj}
312
Set $T_{next}=T_f+T_d+T_{adj}+T_{os}$
314
Is Current Clock Time > T_{next}?
NO
YES
316
Decompress Next Video Frame to Decompression Buffer
318
Copy Decompression Buffer to Frame Buffer A or B Per Pointer
320
Overlay Any Additional Display Objects to Buffer Indicated by Pointer (A or B)
322
Display Frame in Pointer Indicated Buffer
324
Flip Frame Buffer Pointer to Other Buffer (A or B)
326
ADD T_{adj} to T_{os}
328
Are There Any More Frames?
YES
NO
330
END

Fig. 3

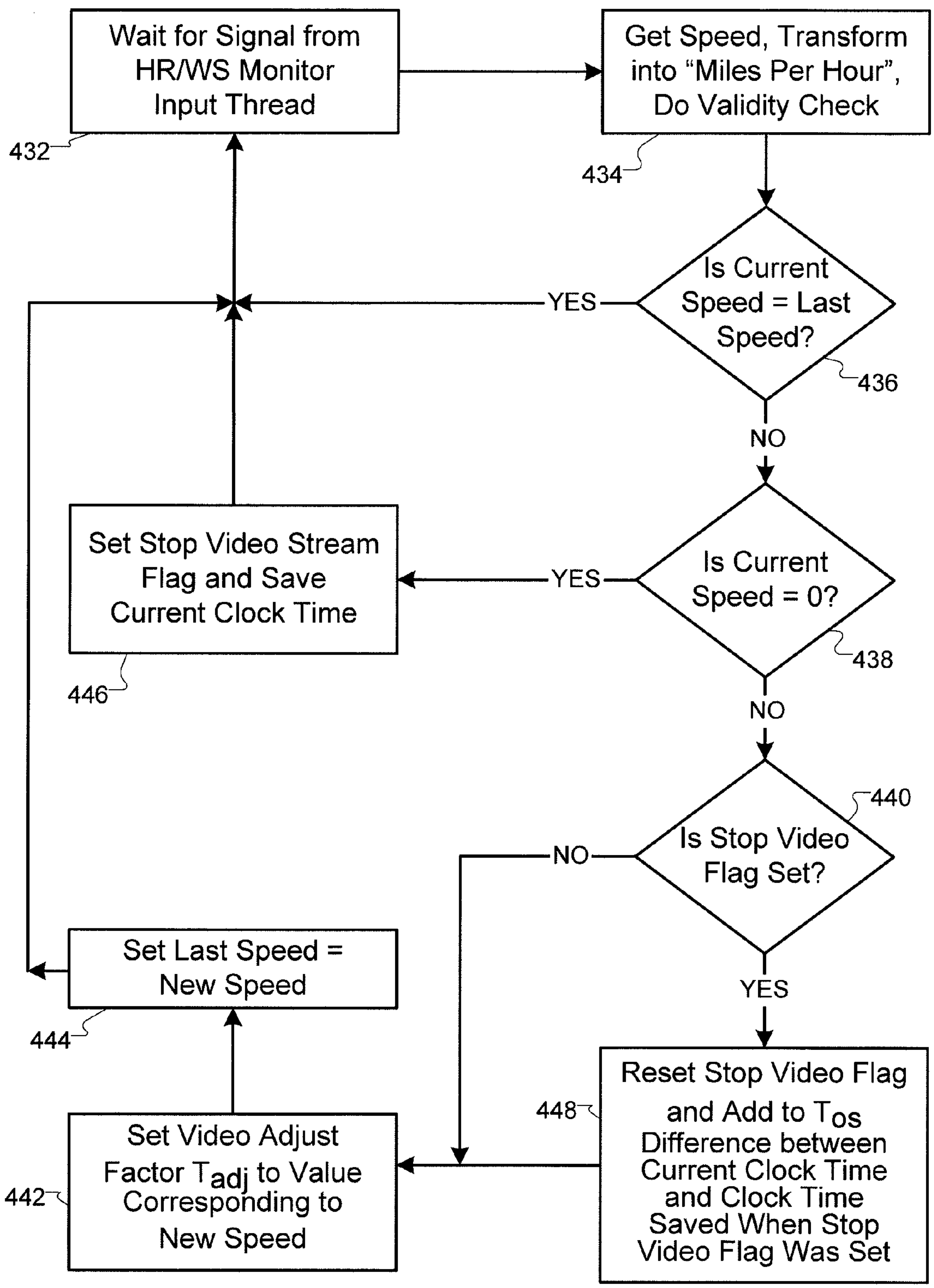

Wait for Signal from HR/WS Monitor Input Thread
432
Get Speed, Transform into "Miles Per Hour", Do Validity Check
434
Is Current Speed = Last Speed?
436
YES
NO
Is Current Speed = 0?
438
YES
Set Stop Video Stream Flag and Save Current Clock Time
446
NO
Is Stop Video Flag Set?
440
NO
YES
Set Last Speed = New Speed
444
Reset Stop Video Flag and Add to Tos Difference between Current Clock Time and Clock Time Saved When Stop Video Flag Was Set
448
Set Video Adjust Factor Tadj to Value Corresponding to New Speed
442

Fig. 4

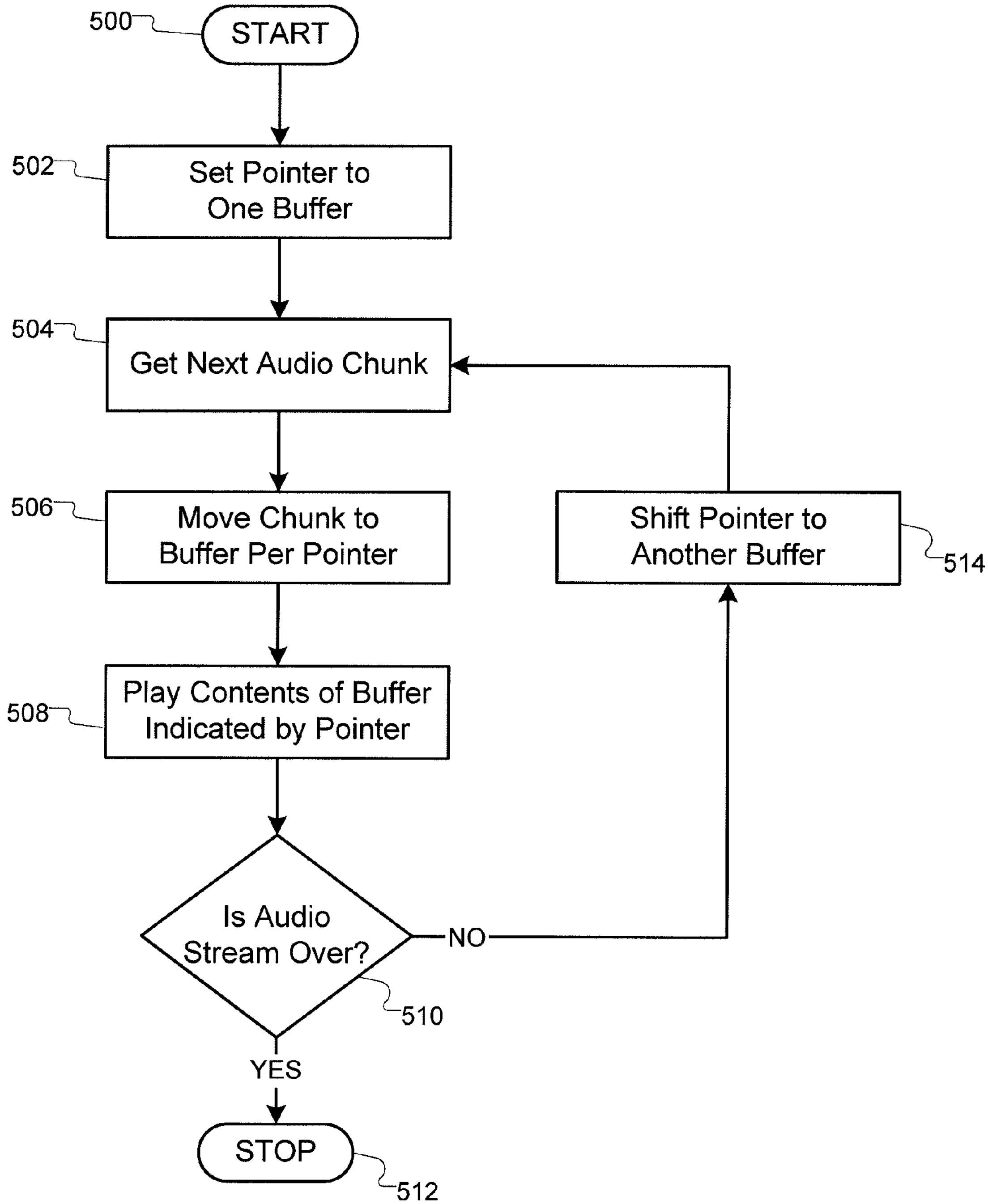

500
START
502
Set Pointer to One Buffer
504
Get Next Audio Chunk
506
Move Chunk to Buffer Per Pointer
508
Play Contents of Buffer Indicated by Pointer
Is Audio Stream Over?
510
NO
Shift Pointer to Another Buffer
514
YES
STOP
512

Fig. 5A

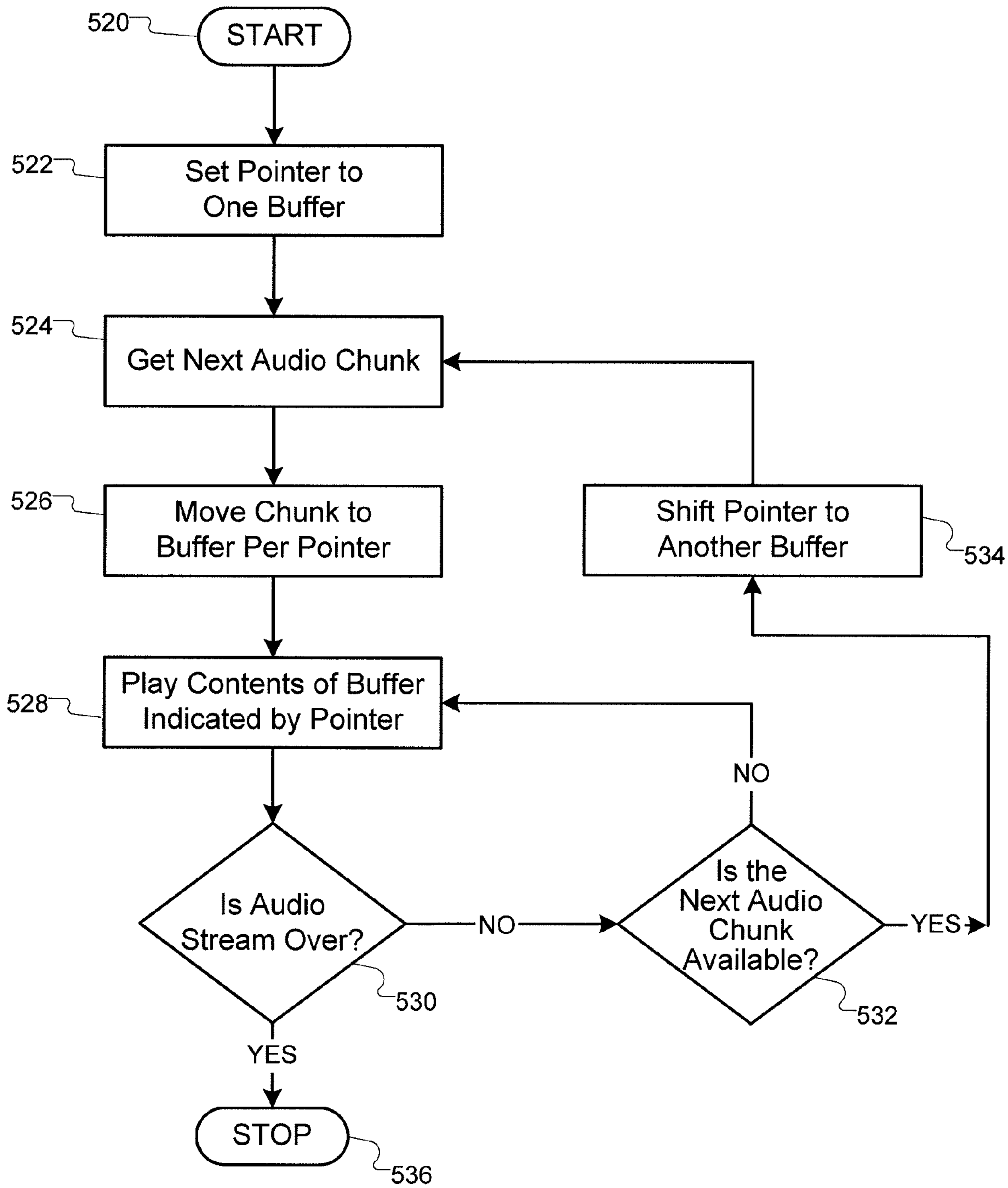

520
START
522
Set Pointer to
One Buffer
524
Get Next Audio Chunk
526
Move Chunk to
Buffer Per Pointer
Shift Pointer to
Another Buffer
534
528
Play Contents of Buffer
Indicated by Pointer
NO
Is Audio
Stream Over?
NO
Is the
Next Audio
Chunk
Available?
YES
530
532
YES
STOP
536

Fig. 5B

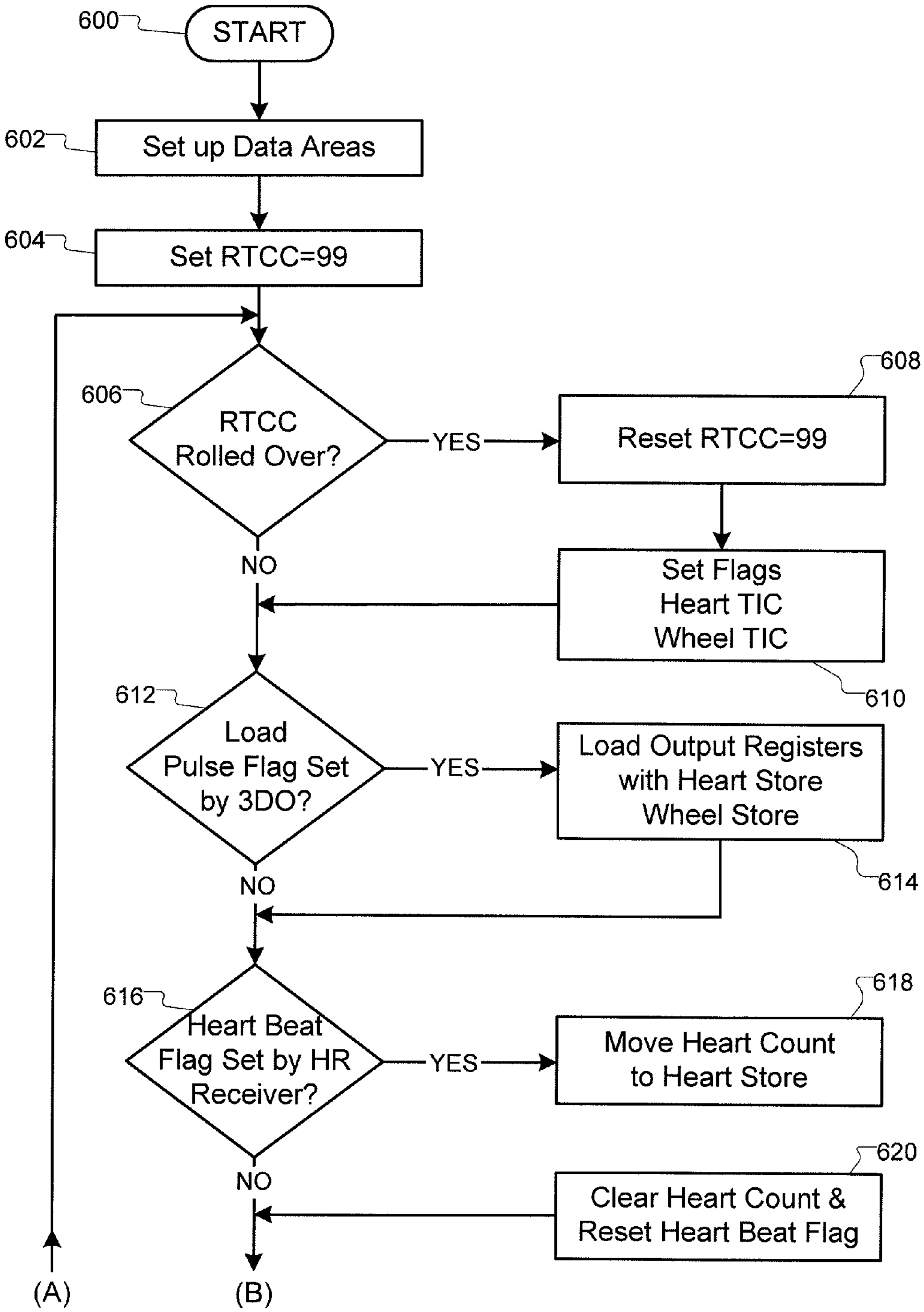

600
START
602
Set up Data Areas
604
Set RTCC=99
606
RTCC Rolled Over?
YES
608
Reset RTCC=99
NO
Set Flags Heart TIC Wheel TIC
610
612
Load Pulse Flag Set by 3DO?
YES
Load Output Registers with Heart Store Wheel Store
NO
614
616
Heart Beat Flag Set by HR Receiver?
YES
618
Move Heart Count to Heart Store
NO
620
Clear Heart Count & Reset Heart Beat Flag
(A)
(B)

Fig. 6A

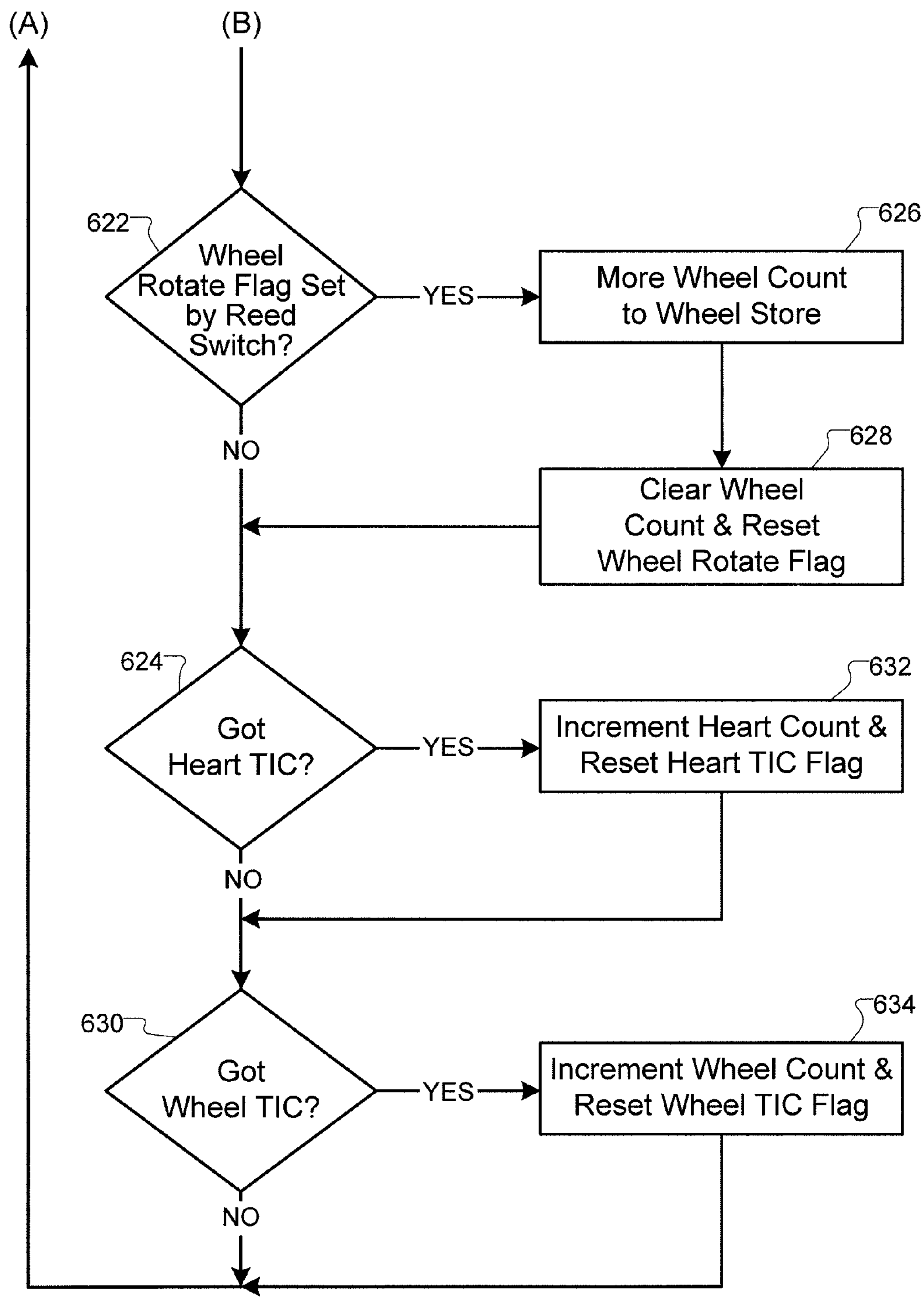

(A)
(B)
622
Wheel Rotate Flag Set by Reed Switch?
YES
NO
626
More Wheel Count to Wheel Store
628
Clear Wheel Count & Reset Wheel Rotate Flag
624
Got Heart TIC?
YES
NO
632
Increment Heart Count & Reset Heart TIC Flag
630
Got Wheel TIC?
YES
NO
634
Increment Wheel Count & Reset Wheel TIC Flag

Fig. 6B

SYSTEMS AND METHODS FOR OPTIMIZING ONE OR MORE AUDIO TRACKS TO A VIDEO STREAM

CROSS-REFERENCE

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 61/110,559, filed Nov. 1, 2008, entitled "System and Method for Optimizing One or More Audio Tracks to a Video Stream," by John Hajime Ford, and U.S. Provisional Patent Application No. 61/248,151 filed Oct. 2, 2009, entitled "System and Method for Optimizing One or More Audio Tracks to a Video Stream," by John Hajime Ford, which applications are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] The results from the 1999-2002 National Health and Nutrition Examination Survey (NHANES), using measured heights and weights, indicate that an estimated 65 percent of U.S. adults are either overweight or obese. The breakdown indicates that an estimated 30% are obese (which is defined as a Body Mass Index of 30 or higher), while 35% are overweight. Body Mass Index ("BMI") is calculated by dividing a person's body weight in kilograms by their height in meters squared. In addition to these statistics for adults, an estimated 15.5 percent of adolescents (ages 12 to 19) and 15.3 percent of children (ages 6 to 11) are estimated to be obese in the United States.

[0003] Although it seems counterintuitive, perhaps as a result of these alarming statistics, the United States is currently experiencing a boom in the health club industry. The number of health clubs in the US has climbed to 26,830 from just 15,372 in the year 2000—a 75% increase. An estimated 41 million Americans belong to health clubs and that number is expected to increase to over 50 million by the year 2010. The 2004 US health club industry comprised a 14.8 billion dollar market, more than double the 7.3 billion dollar market seen just one decade prior. These market changes can be correlated to the American obesity crisis, an appearance focused culture, and the increasing health awareness of the population, and are not expected to slow or stop in the foreseeable future.

[0004] As reported by the Centers for Disease Control and Prevention (www.cdc.gov), physical activity can bring many health benefits. In fact, it has been found that people who enjoy participating in moderate intensity or vigorous intensity physical activity on a regular basis lower their risk of developing coronary heart disease, stroke, non-insulin dependent (type 2) diabetes mellitus, high blood pressure, and colon cancer by 30-60% (US DHHS, 1996). Additionally, active people have lower premature death rates than people who are the least active. Even among frail and older people, mobility can be improved through physical activity. Butler, R N, et al., "Physical Fitness: Benefits of Exercising for the Older Patient" Geriatrics 53(10): 46-52 (1998). Researchers have even found a correlation between walking and a lower incidence of Alzheimers.

[0005] One trend has been the development of dozens of completely new types of group fitness that emerge each year. These fitness classes are typically designed to combine two popular forms of fitness or activities into one class. For example, YogaSpin, a combination of Yoga and group stationary cycling, Extreme Boot Camp, Cheerleading School, Cycling Karaoke, and countless variations based on the popular Cardio Kickboxing and Pilates exercise platforms.

[0006] Another trend that has been noted in the industry is that when people work out with another person, their effort level tends to increase as they try to match the effort of their work-out partner. That benefit is not realized by persons working out alone, for example, on a treadmill.

SUMMARY OF THE INVENTION

[0007] A solution is needed to provide a mechanism for people working out alone to attain a training benefit of working out with a work-out partner.

[0008] An aspect of the invention provides a system that detects the movements in an exerciser's repetitive movement pattern that, when pre-recorded audio footfall sound files are played, most closely support the illusion that the user is generating the sounds with their own "virtual" footfalls, thus creating an enhanced virtual exercise experience. The system generates a signal to communicate the virtual footfall timing with a media playback system, and plays back media files that support the virtual exercise experience.

[0009] An aspect of the invention is directed to an exercise system. The exercise system comprises: a video playing device in communication with a central processing unit and a user input interface connected thereto adapted and configured to receive one or more inputs from a user and transmitting the input to the central processing unit; a prerecorded video frame sequence encoded onto a storage medium in communication with and playable on the video playing device; a video monitor in communication with the video playing device for displaying the prerecorded video frame sequence reproduced by the video playing device; a video frame rate controller configured to vary a rate of display of sequential frames in the video frame sequence reproduced by the video playing device on the monitor in response to the one or more inputs from the user wherein each of the recorded video frame sequences includes a frame time stamp and the video frame rate controller is adapted to generate a variable time adjustment factor in proportion to the one or more inputs from the user and a adjustor adapted to apply a factor to the frame time stamp to determine a modified time at which the next video frame sequence is to be displayed; two or more audio rate controllers configured to vary a rate of delivery of two or more audio files in response to a signal from user interface rate detector wherein the rate of delivery of the two or more audio files are delivered asynchronous to each other; and an exercise device. In some aspects, the video frame rate controller is adapted and configured to comprise a computer program stored on a storage medium with the prerecorded video frame sequence. In such configurations, the program is operable, for example, with the central processing unit in the video playing device when the prerecorded video sequence is played to modify the frame display rate in response to the signal from the user interface rate detector. Additionally, the signal from the user interface rate detector is one or more of a biological parameter measurer, and an exercise device detector. Suitable exercise devices include, for example, a bicycle, a stair stepper, and an elliptical trainer.

[0010] Another aspect of the invention is directed to an apparatus for engaging a user of an exercise device interactively in viewing a video frame sequence of an activity on a video monitor. The apparatus comprises a video player in communication with the video monitor adapted and configured to play a video frame sequence on the video monitor; a detector adapted and configured to detect a rate of exercise by the user on the exercise apparatus and transmitting a signal proportional to the rate of exercise; a video controller in communication with the video player adapted and configured to receive the signal proportional to the rate of exercise and transmit a signal generated in response to the signal proportional to the rate of exercise to the video player wherein the video player adjusts the rate at which the video frame sequence is displayed; and one or more audio controllers in communication with an audio player adapted and configured to receive the signal proportional to the rate of exercise and transmit one or more signals generated in response to the signal proportional to the rate of exercise to the audio player wherein the audio player adjusts the rate at which the audio is played. Suitable exercise devices include, for example, a bicycle, a stair stepper and an elliptical trainer. Moreover, in some configurations, the signal from the user interface rate detector is one or more of a biological parameter measurer, and an exercise device detector. Additionally, the interface rate detector is a heart rate signal receiver for receiving a signal from a transmitter worn by the user and generating a signal usable by the video player for displaying a user's heart rate on the display.

[0011] Still other aspects of the invention are directed to a method of controlling a video frame sequence display rate of a prerecorded video playback sequence in a device in response to an external signal, in which each video frame has a unique frame time stamp and a duration time stamp indicating the time between successive frames. The method typically comprises the steps of: a) accessing the duration time stamp for a current video frame; b) determining from the external signal an adjustment value for changing the display rate; c) obtaining a modified duration time to a next frame by adding the adjustment value to the duration time stamp; d) displaying the next frame when the modified duration time has passed; e) accessing the duration time stamp for a current audio data packet; f) determining from the external signal an adjustment value for changing the rate of delivery of the audio data packet; g) obtaining a modified duration time to a next audio frame by adding the adjustment value to the duration time stamp; h) playing the next audio data packet when the modified duration time has passed; and i) repeating steps a through d for each subsequent video frame and steps e through h for each subsequent audio data packet. The accessing step can further comprise the steps of: i) setting a time offset to current clock time; ii) displaying a current video frame; and iii) accessing a frame time stamp and a duration time stamp for the current video frame. Moreover, the step of determining can further comprise the step of comparing the external signal to predetermined criteria to determine the adjustment value. Additionally, as will be appreciated by those skilled in the art, the external signal is a user variable exercise rate signal. In other embodiments, the step of displaying further comprises the steps of: i) adding the modified duration value to the time offset to obtain a next frame time; and ii) displaying the next frame when clock time exceeds the next frame time.

INCORPORATION BY REFERENCE

[0012] All publications, patents and patent applications mentioned in this specification are herein incorporated by reference to the same extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated by reference.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The novel features of the invention are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present invention will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the invention are utilized, and the accompanying drawings of which:

[0014] FIG. **1**A-C are overviews of a system having a server, a CPU, a monitor, storage media, input devices, etc. which can be used by a user;

[0015] FIG. **2** is block diagram of the apparatus in accordance with the invention shown FIG. **1***b;*

[0016] FIG. **3** is a flow diagram of the video frame rate control program encoded on the video disk;

[0017] FIG. **4** is a flow diagram of a adjustment factor subroutine;

[0018] FIGS. **5**A-B are is flow diagrams of adjustment factor subroutines; and

[0019] FIGS. **6**A-B are logic flow diagrams of an embedded processor in an interface unit.

DETAILED DESCRIPTION OF THE INVENTION

[0020] An aspect of the invention provides a video stream that has one or more audio tracks associated with the video stream, one of which correlates to the sounds of, for example footfalls and which is variable in response to input and which can be used, for example, as a training guide to encourage people to increase their exertion rate as they perceive competing against another person. A second audio track is provided that can correspond to normal ambient-type noise that might be heard by a user in the environment represented by the video stream, music or whatever background noise a user selects. Changes to the video rate correlated audio can be in response to user input or in response to a sensing of a user parameter. In order to achieve the objectives of the invention a variety of components are required: computer systems, components and networks; exercise devices; and software which transforms input from the exercise device and/or computer system into a video and audio output which is delivered to a user.

I. Computer Systems, Components and Networks

[0021] The systems and methods disclosed herein can be achieved using a variety of computer systems, components and networks which are either incorporated into the exercise devices described below or are in communication with the devices.

[0022] FIG. **1**A is a block diagram showing a representative example logic device through which reviewing, manipulating, or analyzing information relating to the present invention can be achieved. Such data can be in relation to exercise, one or more physiological parameters, exertion, or any other suitable parameter desired to be measured of a subject.

[0023] A computer system (or digital device) **100** that may be understood as a logical apparatus that can read instructions from media **111** and/or network port **105**, which can optionally be connected to server **109** having fixed media **112**. The computer system **100** can also be connected to the Internet or an intranet. The system includes CPU **101**, disk drives **103**, optional input devices, illustrated as keyboard **115** and/or mouse **116** and optional monitor **107**. Data communication can be achieved through the indicated communication medium to a server **109** at a local or a remote location. The communication medium can include any means of transmitting and/or receiving data. For example, the communication medium can be a network connection, a wireless connection or an internet connection. It is envisioned that data relating to the present invention can be transmitted over such networks or connections. The computer system can be adapted to communicate with an participant parameter monitor and/or an apparatus on which a participant is engaged in exercise. Additionally, the components of these logic devices can be incorporated, wholly or partially, into an exercise device, as will be appreciated by those skilled in the art.

[0024] A user or participant **122** can optionally also be connected to a variety of monitoring devices, as described below. The monitoring devices can further be adapted and configured to interact with the system. As will be appreciated by those skilled in the art, the computer system, or digital device, **100** can be any suitable device. Other suitable devices capable of being adapted for use in the system described herein include, for example, video iPod (Apple Corp., Cupertino Calif.), or a portable DVD player or DVD Walkman® (Sony Corporation). Such devices would be suitable in a variety of situations.

[0025] In an embodiment, a computer-readable medium includes a medium suitable for storing, analyzing and transmitting target information of interest, such as that information discussed in more detail below. The medium can include a result regarding a disease condition or state of a subject, wherein such a result is derived using the methods described herein.

[0026] FIG. **1**B depicts another exemplary computing system **100**. The computing system **100** is capable of executing a variety of computing applications **138**, including computing applications, a computing applet, a computing program, or other instructions for operating on computing system **100** to perform at least one function, operation, and/or procedure. Computing system **100** may be controlled by computer readable instructions, which may be in the form of software. The computer readable instructions can contain instructions for computing system **100** for storing and accessing the computer readable instructions themselves. Such software may be executed within CPU **102** to cause the computing system **100** to perform desired functions. In many known computer servers, workstations and personal computers CPU **102** is implemented by micro-electronic chips CPUs called microprocessors. Optionally, a co-processor, distinct from the main CPU **102**, can be provided that performs additional functions or assists the CPU **102**. The CPU **102** may be connected to co-processor through an interconnect. One common type of coprocessor is the floating-point coprocessor, also called a numeric or math coprocessor, which is designed to perform numeric calculations faster and better than the general-purpose CPU **102**.

[0027] In operation, the CPU **102** fetches, decodes, and executes instructions, and transfers information to and from other resources via the computer's main data-transfer path, system bus **140**. Such a system bus connects the components in the computing system **100** and defines the medium for data exchange. Memory devices coupled to the system bus **140** include random access memory (RAM) **124** and read only memory (ROM) **126**. Such memories include circuitry that allows information to be stored and retrieved. The ROMs **126** generally contain stored data that cannot be modified. Data stored in the RAM **124** can be read or changed by CPU **102** or other hardware devices. Access to the RAM **124** and/or ROM **126** may be controlled by memory controller **120**. The memory controller **120** may provide an address translation function that translates virtual addresses into physical addresses as instructions are executed.

[0028] In addition, the computing system **100** can contain peripherals controller **128** responsible for communicating instructions from the CPU **102** to peripherals, such as, printer **142**, keyboard **118**, mouse **116**, and data storage drive **143**. Display **108**, which is controlled by a display controller **134**, is used to display visual output generated by the computing system **100**. Such visual output may include text, graphics, animated graphics, and video. The display controller **134** includes electronic components required to generate a video signal that is sent to display **108**. Further, the computing system **100** can contain network adaptor **136** which may be used to connect the computing system **100** to an external communications network **132**.

[0029] Computing system **100**, described above, can be deployed as part of a computer network **150** or can be wholly or partially incorporated into a suitable exercise device, such as those described below. In general, the above description for computing environments applies to both server computers and client computers deployed in a network environment. FIG. **1**C illustrates an exemplary illustrative networked computing environment **100**, with a server in communication with client computers via a communications network **150**. As shown in FIG. **1**B, server **110** may be interconnected via a communications network **150** (which may be either of, or a combination of a fixed-wire or wireless LAN, WAN, intranet, extranet, peer-to-peer network, virtual private network, the Internet, or other communications network) with a number of client computing environments such as tablet personal computer **102**, mobile telephone **104**, telephone **106**, personal digital assistant **108**, and a personal computer **112**. Additionally, an exercise input device **12** is provided in communication with the network environment. In a network environment in which the communications network **150** is the Internet, for example, server **110** can be dedicated computing environment servers operable to process and communicate data to and from client computing environments via any of a number of known protocols, such as, hypertext transfer protocol (HTTP), file transfer protocol (FTP), simple object access protocol (SOAP), or wireless application protocol (WAP). Additionally, networked computing environment **100** can utilize various data security protocols such as secured socket layer (SSL) or pretty good privacy (PGP). Each client computing environment can be equipped with operating system **138** operable to support one or more computing applications, such as a web browser (not shown), or other graphical user interface (not shown), or a mobile desktop environment (not shown) to gain access to server computing environment **100**. An exercise device **12** is in communication with one or more devices shown in the network **150**. The exercise device **12** can be a treadmill (as illustrated), or any other suitable device.

[0030] In operation, a user (not shown) may interact with a computing application running on a client computing environment to obtain desired data and/or computing applications as the user is exercising using the exercise device **12** adapted and configured to communicate with the computing application and/or interact with a biological parameter measurer **144**

adapted and configured to communicate with the computing application via, for example, an interface unit **142**. The data and/or computing applications may be stored on server computing environment **100** and communicated to cooperating users through client computing environments over exemplary communications network **150**. A participating user may request access to specific data and applications housed in whole or in part on server computing environment **100**. These data may be communicated between client computing environments and server computing environments for processing and storage. Server computing environment **100** may host computing applications, processes and applets for the generation, authentication, encryption, and communication data and applications and may cooperate with other server computing environments (not shown), third party service providers (not shown), network attached storage (NAS) and storage area networks (SAN) to realize application/data transactions.

[0031] Biological parameter measurement devices **144** include, for example, devices capable of measuring a biologic function, such as heart rate, blood pressure, blood sugar or glucose levels, body temperature, tissue oxygenation, volume of O_2 (VO2), pulse oximeter measurement (Sp O_2), electroencephalogram measurement (EEG), O_2 saturation, or any other measurement that can be obtained from the participant as would be appreciated by those skilled in the art. See, for example, U.S. Patent Publications U.S. 2005/0166373 entitled Case Structure for Sensor Structure Attachable to and Detachable From a Shoe (Saasko et al.), U.S. 2005/0135039 entitled Electric Circuit and Transmission Method for Telemetric Transmission (Klemetti), U.S. 2005/0130802 entitled Arrangement, Method and Computer Program for Determining Physical Activity Level of Human Beings (Kinnunen), U.S. 2005/0111307 entitled Electronic Wrist Device (Saaski et al.), U.S. 2005/0111306 entitled Portable Wrist-Worn Personal Electronic Device (Saaski et al.), U.S. 2005/0017850 entitled Mechanical Measuring Device and a Measuring Method (Nissala), U.S. 2005/0004436 entitled Method and Device for Weight Management of Humans (Nissala), U.S. 2004/0220738 entitled Portable Personal Data Processing Device (Nissala), and U.S. 2004/0220485 entitled Method and Device for Measuring Heart Rate, and for Manufacturing the Device (Rytky). U.S. Pat. Nos. 6,832,109 entitled Wrist-Worn Device for Displaying and Setting Heart Rate Parameters (Nissala); 6,754,517 entitled Apparatus for Measuring Electrocardiograph Signal (Nissila); 6,714,812 entitled Method of Performing Operating Settings in Heart Rate Measurement Arrangement, and Heart Rate Measurement Arrangement (Karjalainen); 6,687,535 entitled Controlling of Fitness Exercise (Hautala et al.); 6,605,044 entitled Caloric Exercise Monitor (Bimbaum); 6,584,344 entitled Method and Apparatus for Measuring Heart Rate (Hannula); 6,554,773 entitled Method and Arrangement for Blood Pressure Measurement (Nissila); 6,553,247 entitled Electrode Belt of Heart Rate Monitor (Rytky); 6,540,686 entitled Measurement Relating to Human Body (Heikkila et al.); 6,443,904 entitled Determination of Stress Level of Fitness Exercise (Nissila); 6,954,661 entitled Blood Sugar Measuring Apparatus (Cho et al.); 6,746,415 entitled Method of Blood Constituent Monitoring Using Improved Disposable Eletrocorporeal Conduit (Steuer et al.); 5,251,632 entitled Tissue Oxygen Measuring System (Delpy); 4,368,740 entitled Physiologic Analyzer (Binder); 6,912,413 entitled Pulse Oximeter (Rantala et al.); 6,879,850 entitled Pulse Oximeter with Motion Detector (Kimball); 6,829,496 entitled Blood Component Measurement Apparatus (Nagai et al.); 6,950,697 entitled Electroencephalagram Acquisition Method and System (Jordan); 6,829,502 entitled Brain Response Monitoring Apparatus and Method (Hong et al.); 6,510,340 entitled Method and Apparatus for Encephalography (Jordan); 6,909,912 entitled Non-Invasive Perfusion Monitor and System, Specially Configured Oximeter Probes, Methods of Using Same, and Covers for Probes (Melker); and 6,850,789 entitled Combination SPO2/temperature Measuring Apparatus (Scheitzer Jr., et al.). Parameter measurement devices also include, for example, a participant monitoring their pulse manually by placing a finger, for example, on the carotid artery or near the wrist to determine the number of beats per minute. See also, U.S. Pat. No. 5,170,780 to Rosenfeld for Method of Credibility Assessment Based on Feedback-Elicited P3 Responses of Brain and European Patent Publication EP 1510175 A1 to Kostucki for Exercise Manager Program.

II. Exercise Devices

[0032] The systems and methods disclosed herein can be achieved using a variety of exercise devices which are modified to provide information to one or more computer systems, components and networks on which software is provided which is adapted and configured to transform one or more inputs, e.g., from an exercise device, parameter sensor, and/or computer system into a video and audio output which is delivered to a user.

[0033] As will be appreciated by those skilled in the art, footfalls or movement of a user can be sensed in a variety of ways. The mechanism for sensing footfalls or movement of a user will vary by machine type. For the three major types of fitness machines, treadmills, elliptical machines, and stair steppers, there may not necessarily be an actual footfall (as in the case with elliptical machines). Additionally, there are also various hybrid machines which are a mix of these three main types of machines. The elliptical machines and stair steppers do not have a real footfall to sense, as the user's motion in reality is a fluid elliptical pattern in the case of elliptical machines, and a repetitive vertical (but fluid with no actual foot impact) motion on a stepper.

[0034] Treadmills: One mechanism that can be used would be to sense the user via, for example, the extra force exerted downward on the treadmill, or certain treadmill components, by the footfall of the user. A force sensor may be a piezoelectric device that converts force directly into a voltage differential, which in turn can be correlated to a controller to provide a mechanism for providing sensory feedback for the user. Other force sensors that produce electric signals as an output would be possible, including for example capacitative force sensors, optical-electric strain gauges, and others. Another mechanism for sensing footfalls with a treadmill includes, for example, one or more of: providing ammeters to detect increased load on the treadmill motor, tension sensors (electromagnetic or even piezoelectric) to detect sudden changes in belt tension, providing acoustic pickup to sense the sound of the footfall (a simple condenser microphone, electret microphone, dynamic or inductance type microphone), providing user-worn sensors such as accelerometers to detect the motion of the users feet or body (and which can communicate—wired or wirelessly—with the system), providing optical sensors to detect the position of the users' body—either with an imaging system or through beam-interruption detection (for example, with infrared lasers and photoelectric sensors, or with a passive imaging system that can recognize the user's body position), providing a sensor worn by the user that is a foot/leg position sensor such as the that used in gaming systems such as the Nintendo Wii®, providing a charge sensor that detects contact by a user (similar to touchscreen technology), providing a sensor that detects variances in the speed of the treadmill belt (which will slow slightly on foot impact). See, for example, U.S. Pat. No. 7,507,187 to Dyer et al. for Parameter Sensing System for an Exercise Device; and U.S. Pat. No. 6,336,891 to Fedrigon et al. for Interactive Exercise Pad and System. Treadmills are described more fully in, for example, U.S. Pat. Nos. 7,575,537 entitled Dual Direction Exercise Treadmill for Simulating a Dragging or Pulling Action with a User Adjustable Constant Static Weight Resistance; 7,563,203 entitled Treadmill with Cushion Assembly; and 7,367,926 entitled Treadmill with Moveable Console.

[0035] Elliptical Trainers: In one aspect, the elliptical could be configured to enable a "virtual footfall" to be sensed on the elliptical, or the moment at which a footfall sound would create the most effective representation of running or walking, is a position sensor that triggers when, for example, an elliptical pad is at its forward-most point in its elliptical movement pattern, on its down stroke, or reaches its lowest point. Alternately, speed sensors could determine when the forward motion of a stride reaches zero, which would also correspond to the furthest forward part of the stride but would accommodate inconsistent stride lengths. Elliptical trainers are described more fully in, for example, U.S. Pat. Nos. 6,436,007 entitled Elliptical Exercise Machine with Adjustment; 6,361,476 entitled Variable Stride Elliptical Exercise Apparatus; and 6,077,196 entitled Adjustable Elliptical Exercise Apparatus.

[0036] Variants could include a differential position sensor, sensing the point at which the pads are furthest apart, which is the same as the point at which either pad is furthest forward. Other ways to determine footfall on an elliptical include, for example, one or more of providing a speed sensor that senses when the elliptical pad's horizontal speed is zero (it is exactly at the moment in the elliptical movement pattern in which it is moving neither forward nor back). Speed sensor could also detect when the foot pad's vertical acceleration is highest; providing a weight/force/pressure sensor that detects the moment at which the greatest weight/force/pressure is being applied to the elliptical pad, which will correspond with the beginning of downward motion on the front most pad and thus the virtual footfall; providing a wireless/wired worn-sensor methods as mentioned above; providing optical/audio/infrared/etc sensors as mentioned above in treadmill section; or using the above systems to detect speed as it approaches zero.

[0037] Stair Stepper Exercise Devices: One mechanism to detect footfall or an equivalent of footfall on a stepper would be, for example, a position sensor that detects the point at which one of the step pads/levers is at or begins descending from its highest point. Steppers frequently have traditional step counters built-in and these could also be piggybacked upon. All of the methods mentioned above for ellipticals could be adjusted to work with steppers with a vertical fluid motion rather than an elliptical motion, including methods that detect the pad's speed approaching zero. The trigger point for the footfall would be the point at which either footpad begins to descend from its highest point. This is also the point at which the most force/pressure/weight is on the footpad and when the footpad begins downward acceleration. Stair stepping devices are described more fully in, for example, U.S. Pat. Nos. 7,153,238 entitled Stairclimber Apparatus Pedal Mechanism; and 5,399,134 entitled Stair Climbing Exercise Apparatus.

[0038] Hybrid Exercise Devices: Combinations or variants of the methods above could be used on hybrid machines to equal effect.

III. Apparatus Configured to Correlate Audio and Visual Signals

[0039] In this system, playback of one or more audio media files is triggered by one or more of the sensors described above. A signal generated by the sensor is detected by the media playing device, which then plays an appropriate media file. In addition to audio media files, visual signals and/or media files might be generated to correspond to the audio playback (for example a graphical shoe that blinks on the bottom portion of the screen each time the footfall is sensed).

[0040] Latency, or lag between the time at which a footfall is sensed and the time at which the audio file playback is initiated, can greatly diminish the effectiveness/enjoyment/motivation of the experience. Latency, even measured in amounts as small as tens of milliseconds, can alter the illusion created by the product of a user's actual footfalls. One method of addressing latency is to use software/system elements to make the playback of audio files predictive, rather than timed to correspond with specific occurrences of actual footfalls. One variant of this method would be to: characterize the system latency through product testing, determine how much latency exists for each machine through testing and then, during the exercise session, determine the cadence of the user, such as by using the sensors sensing the time between a plurality of footfalls and using this information to create an average footfall timing pattern. Thereafter begin playing the footfall audio files in accordance with the rolling average time between steps generated by the above.

[0041] Apply the known system latency determined through step 1 of the method described above to advance the timing of the audio file playback by an amount equal to the system latency. Then allow the user to use any number of possible input devices, such as buttons, levers, touch screen elements, etc, to adjust the timing of the predictive audio playback up or down by small increments to adjust the latency correction as needed.

[0042] Another variant of this method would be to not predict the moment associated with the actual footfall, but to use any number of the sensor methods above to sense a moment that precedes the moment of actual footfall by a fixed or predictable amount of time. Thus the signal to play the footfall audio file would be generated in advance, and taking known system latency into account, as in the first variant, the playback could be timed to match the actual moment of footfall.

[0043] Another variant of this method might be to "cover up" the latency to some extent by playing an audio file that "fades up" or increases in volume throughout playback. This could lead the user to believe that the audio file is timed correctly, but just happens to be initially inaudible because of the nature of the sound.

[0044] To create an effective virtual experience, the audio files played back by the footfall triggers could be configured to match the sounds of real footfalls pre-recorded on terrain similar to that shown in a video media presentation on the machine's display. The footfall audio files could thus vary throughout the course of a virtual exercise experience based on the various types of terrain being displayed. The characteristics of the audio file playback could be altered to enhance the experience in several ways:

[0045] The volume of the footfall audio file playback, or some portion of it, could be adjusted interactively based on movement speed or other exercise parameters, such as to represent louder footsteps when running faster.

[0046] The length or amount of the total footfall audio actually played back could be interactively adjusted based on movement speed or other exercise parameters, such as to represent quicker, lighter steps when running faster. This could occur by either cutting off playback (or combining cut-off with a fade-out of volume) or by speeding up playback beyond the files original speed to achieve shorter playback of the entire audio file.

[0047] Standard stereo audio playback functionality could be used to pan footfall audio playback to the right or left speakers in the audio system alternately to more accurately represent the virtual experience by representing the right or left footstep.

[0048] This raises issues of sensing the left/right footstep, rather than footsteps in general. In the case of steppers and ellipticals, this is a simple task, as the footpads are independent of one another and any of the discussed sensing methods can easily be adjusted to sense the footfall of either the left or right pad. In the case of the treadmill, the belt is a solid single element, and sensing either the left or right is more challenging. There are however methods that could do so, such as via multiple pressure/weight/force sensors that are positioned on different sides of the belt, differential tension/drag sensor that is capable of detecting greater tension on one side of the belt, other possible methods.

[0049] The specific audio file played could be varied based on an exercise parameter, such as speed, incline, or resistance. The sound of an actual footfall will be different depending on whether the person generating that footfall is moving fast or slow, or over flat or steep terrain, for example. Thus footfalls pre-recorded on the same type of terrain might be played with different characteristics to adjust for this as noted above, and/OR different pre-recorded footfalls might be played that more accurately represent the exercisers parameters over the same terrain. For example, there could be a sound for fast movement over gravel, another file for slow movement over gravel, and yet another for movement over steep gravel.

[0050] Alternatively, when a series of audio footfalls are played back to exercisers, many exercisers experience an instinctual motivation to match the sounds of these footfalls with their actual steps. Thus a motivational/coaching system using the audio techniques described herein could be greatly enhanced through the use of programmed footfall patterns.

[0051] In one implementation of this system, pre-recorded footfalls with varying characteristics to represent varying terrain or exercise parameters as described above, could be played independently of the activity of the exerciser, in a pre-determined pattern which is known to support the motivation of the exerciser.

[0052] The timing of these footfalls could be adjusted by the user themselves, or by the program, based on the program itself or the program in conjunction with information input by or detected from the user (such as desired difficulty level, height, age, heart rate, or other parameters).

[0053] The timing of the footfalls could be manually adjustable by the user through standard input devices such as buttons, touch screen elements, etc.

[0054] FIG. **2** is a block diagram of an apparatus in accordance with the invention shown in FIG. **1**. The apparatus **210** includes the exercise machine **12** connected to an interface unit **236** which is in turn connects to the CPU **202** of a player. In one configuration a prerecorded data storage medium **248**, such as a compact laser disc (CD), is inserted into a player **220**. This CD contains media data including a set of digitized video frames and audio data packets and an encoded program which modifies the player control program **250**. In other configurations, the pre-recorded data is contained on a storage medium which is streamed to a local device via the Internet or an intranet.

[0055] For purposes of illustrates, it will be appreciated that the CPU **202** includes a control program **250**, a content buffer **252** which decodes and decompresses the data stream read from, for example, the CD **248**, a dashboard display overlay generator **254**, and a set of two or more display buffers **256** and **258**. The player **220** also optionally includes inputs for signals receivable from, for example, a remote system CPUs **260**.

[0056] Each CD can be configured to include a program which manipulates the control program **250** to manipulate the rates at which the audio visual are displayed.

[0057] Additional displays, such as real time, or near real time, exercise inputs from an interface unit **232** such as speed, cadence, total distance traveled, lap distance, calories burned, time elapsed, time remaining, and the like can be provided. Moreover, these parameters can be calculated and displayed on, for example, a 'dashboard' overlay on the visual monitor **218**. Such parameters can be generated in overlay block **254** and fed to the display buffers **256** and **258**. The overall control of the video sequences, and the start/stop of the exercise overlay program can be manipulated via a suitable user input, such as keypad **236** mounted on an interface unit **232**.

[0058] The rate at which the video is displayed and one or more audio sequences are played in accordance with the present invention is controllable by a program shown in block diagram form in FIG. **3**. As will be appreciated by those skilled in the art, the program can be encoded on a CD and operated on the operating control program **250** in the CPU of the player **220**. Alternatively, the program can be stored on a remote network location that is accessible locally.

[0059] The present invention is adapted and configured to utilize one or more of each video and audio recorded sequences. Suitable sequences include those which can be recorded using a POV (Point of View) videotape camera mounted on an athlete's head or vehicle such as a bicycle. Each video frame recorded is assigned and has recorded with it a unique frame time stamp value and a duration stamp value for accessing the next frame packet of data upon playback. Typically, in real time recording, the duration stamp is a constant value, for example, about 8 milliseconds. These frame stamp and duration values function to allow a playback apparatus to sequence and time the reproduced display. The audio may be interlaced with the video or may be a separate track recording. The recorded sequence of video and audio are then digitized and recorded on a video CD along with the control program described below and shown in the Figures herein.

[0060] The basic effect of the control program of the present invention is to control the rate at which the video frame is played and to correlate the playback to the exercise rate of the user on the exercise device **12** that is in communication with the system. Therefore as the exercise rate increases, the frame rate of display increases. This creates the experience for a user that the scenery changes at a rate equivalent, or near equivalent, to the rate at which the scenery would change if the user were, for example, cycling or running at that rate where the video display was captured. Similarly, as the exercise rate of a user decreases, the video displays scenery at a slower and slower rate, until the user stops and the scene displayed stops also. Thus the user achieves a visual sensation similar to that of actually traveling through the scenery shown in the video.

[0061] The process flow begins operation **300**, for example, when the user begins pedaling the bicycle or walking on the treadmill. Thereafter, the program can set, in operation **302**, a cumulative time offset (T_{os}) to the current clock time of the CPU. This time offset tracks the total difference in time that the program modifies the video sequence due to the exercise rate of the user.

[0062] The program next queries, in operation **304**, whether a stop video stream flag is set. However, if the Stop Video Flag is set, as when the user stops pedaling to rest for a period of time or stops running on the treadmill, a control passes to a wait operation **306**. Wait operation **306** can, for example, be a process delay on the order of 10 milliseconds, after which the query in operation **304** would then be repeated. If the Stop Video Stream flag is not set, control passes to operation **308**.

[0063] In operation **308**, the current frame time stamp value (T_f) is retrieved and the current frame duration value (T_d) is retrieved from the decompressed stream data in content buffer **452**. Then the Adjustment value (T_{adj}) is obtained, in operation **110**, from the program sequence shown in FIG. **4**. In operation **312**, the variable T_{next} is set equal to $T_f+T_d+T_{adj}+T_{os}$. This is the clock time at which the next frame should be decompressed into the decompression buffer **452**.

[0064] In operation **314**, the query is made as to whether the current CPU clock time is equal to or greater than T_{next}. If the clock time is not greater to T_{next}, then the system continues to wait **306**. If the clock time is greater than T_{next}, then the next video frame is decompressed and added to the decompression buffer **316** in the content buffer block **252** of the player CPU **202**. At this point, the content of the decompression buffer is copied to a frame buffer, which in this case is either frame buffer A or frame buffer B **320**, whichever is pointed to by a pointer. The pointer is adapted and configured to alternate between the two frame buffers.

[0065] As soon as the decompression buffer is copied to the pointed to frame buffer **318**, control is passed to operation **320**, where display objects such as the optional dashboard indicating the current heart rate, pulse icon and exercise status parameters, are overlaid into the buffer indicated by the pointer. Once the frame buffer contents are overlaid, control shifts to operation **322** and the contents of the frame buffer pointed to is sent to the video display or television set.

[0066] In operation **324**, the frame buffer pointer is switched to the other buffer. In operation **326**, the contents of T_{adj} are added to the T_{os} register so as to keep track of total adjustments to the sequence. Control then passes to operation **328** where the program queries whether there are any more video frames in the sequence. If there are none, the program ends in operation **330**. If there are additional frames, control passes again to the wait operation **306** and the above steps are repeated as many times as necessary to achieve the desired output.

[0067] Video reproduction rate thus is modifiable by adding time or subtracting time from a prerecorded video frame duration stamp value. In other words, the value of T_{adj} changes and thus modifies the effect of T_d. FIG. **4** describes an example of how T_{adj} can be modified. For example, the sequence of operations in FIG. **4** occurs continuously to provide a value of T_{adj} corresponding to a user's exercise rate. As will be appreciated from the examples below, the manner of corresponding the video stream to a user's exercise rate can be accomplished in a variety of ways and from a plurality of inputs, including a biological parameter measurement device **144** (as shown in FIG. **1**B), or from the rate at which the exercise device is operated by the user, or from a rate at which a user is moving as detected by the device.

[0068] By way of an illustrative example, a sequence begins in operation **432** where, for example, the wheel speed input signal from the wheel pickup is fed through the interface unit **142** into the CPU **102** through an input such as keypad **118**. The current speed, corresponding to miles per hour or kilometers per hour, can be obtained from the raw signal in operation **434**. So, for example, the current speed can be continually updated as long as there is a wheel speed thread from the interface unit **142**. In addition, validity checks are performed in this operation to ensure that the signal is, in fact, a correct wheel speed signal.

[0069] Control then shifts to operation **436** where a query is made whether current speed equals the last speed. If so, control returns to operation **432** for another input from wheel speed. If not, the query is made in operation **438** whether current speed is equal to zero. If not, control transfers to operation **440** where the query is made whether the Stop Video Flag is set. If this flag is not set, then control passes to operation **442** where the video adjust factor, T_{adj} is set to a table value corresponding to the current speed. Values can be empirically determined to give the appearance to the user of smooth transitions between frames and may be different for different operating systems and different video player machine speeds.

[0070] Control then shifts to operation **444** where Last Speed is set equal to New Speed and control again transfer to operation **432** where another signal from the wheel sensor is awaited. If the Current Speed is equal to zero in operation **438**, control transfer to operation **446** where the Stop Video Stream flag is set and current clock time is saved. The Stop Video Stream flag may also be required in operation **304** to cover the situation where the user stops to rest after beginning a sequence. In that instance, the current clock time when this flag is set must be saved because, after the start, in operation **300**, clock time is continuously running. Therefore, if the user stops momentarily, requiring the video sequence to freeze, the duration of the stopped period must be added to the time offset in order to keep the sequence operating properly based on current clock time.

[0071] When the user again using the device by, for example, pedaling, a signal will be produced in operation **432**. Control then sequences through operations **434** and **436** with "no" answers. In operations **440**, the answer is "yes" to the query whether the Stop Video Flag is set Control then transfer to operation **448** resets the Stop Video Flag and adds to T_{os} the elapsed time between the current clock time at flag reset and the clock time saved when the Stop Video Stream flag was previously set. This addition to T_{os} accounts for the lapse while the user was idle. Control then transfers again to operation **442** where the video adjust factor T.sub.adj is appropriately set as described above.

[0072] The sequence illustrated in FIG. **4** is continuous and proceeds whenever there is a signal from the wheel speed monitor input thread from the interface unit **142**. Therefore this program sequence is constantly updating during the exercise activity. In contrast, the sequence illustrated in FIG. **3** operates during the time that a video frame is available to be displayed.

[0073] Turning now to FIGS. **5***a* and **5***b*, flow diagrams are provided illustrating two versions of an audio portion of a prerecorded sequence. There are basically two ways in which the audio data is encoded on the video compact disc. The audio data chunks may be in a separate file from the video file or the audio data chunks may be interleaved with the video frame data chunks in the same file. The FIG. **5***b* flow diagram is for processing audio data chunks which are stored in a separate audio data file on the CD. FIG. **5***a* provides a flow diagram for play of audio data chunks which are interleaved with the video frame data in the same file. Either case may be used dependent upon variables such as buffer space and storage medium drive speed. The audio program code is encoded on the CD as is the video program code described above with reference to FIGS. **3** and **4**.

[0074] Referring now to FIG. **5***a*, when the video stream starts, the audio stream starts in operation **500**. A digital pointer is set to one of at least two audio buffers in operation **502** and control passes to operation **504** where an audio data chunk is retrieved from the decompression content buffer **252**. The audio data chunk is then loaded into the buffer pointed to by the audio pointer in operation **506**. As soon as the audio chunk is loaded into this buffer, contents of the buffer begin to play in operation **508**. Meanwhile, operation control is passed to operation **510** where the query is made whether the audio stream is complete. If so, control passes to operation **512** and the audio play stream stops. If the audio stream is not complete, control passes to operation **514** where the pointer is shifted to the next buffer and control is passed back to operation **504**. This process repeats until there are no more audio data chunks signifying that the audio stream is complete. In the case just described, the audio continues to play, even when the video slows in response to the actions of the user on the exercise device **12**.

[0075] Referring now to the interleaved audio flow diagram in FIG. **5***b*, when the first video frame is decompressed and loaded into the display buffer as described above with reference to FIGS. **3** and **4**, the audio stream control begins in operation **520**. First, a pointer is set to one of at least two audio buffers in operation **522**. Control then passes to operation **524** where an audio data chunk associated with the current video frame is retrieved from the decompression content buffer **252**. This data chunk is then loaded into the audio buffer pointed to in operation **526** and play of this audio chunk immediately begins in operation **528**. At the same time, control shifts to operation **530** where the stream is queried to determine if the audio stream is complete. If not, the query is made, in operation **532**, whether the next audio data chunk is available.

[0076] Thus, the query in operation **532** is whether the next video frame has been called for display. This becomes important when the user is slowing down the video display by reducing his or her exercise rate, e.g. pedaling slower. If the next video frame has not been called, the next audio data chunk will not be available. In this case, operation **532** transfers control back to operation **528** and the current audio data chunk is replayed. Where the audio is wind noise, sounds of the road, or natural background noise in the country, the user will not likely be able to distinguish that the audio is being "looped back". Once the next video frame is called, the query in operation **532** will transfer control to operation **534** where the pointer is set to another buffer. Control then transfers back to operation **524** to get another audio data chunk and operations **526**, **528**, **530**, and **532** are repeated until the last of the audio stream is processed. In this case, control is transferred to operation **536** where the audio play is stopped.

[0077] The audio buffers provide a smooth sequencing of audio chunk play. In the present invention, a plurality of audio can be played with the video. For example, a first audio can be played at a constant rate independent of the video frame, while a second audio is played at a rate which corresponds to the rate at which the video is played. This facilitates a first audio pitch and tempo remaining a pleasing audio signal, as would be perceived at the location while a second audio pitch changes to correspond to the pace at which footfalls, for example, would occur at the rate of exercise perceived by the user, while a third audio can occur at a rate intended to mimic a training pace or quickening pace of a training partner in response to a differential input by a user or calculated based on user parameters such as age, health and training objectives. Also, as the user slows down, the on-location sounds would not change appreciably. However, the audio volume could be made to increase or decrease as the user increases or decreases speed respectively. Therefore looping these audio chunks of wind and road noise back during slow exercise periods as described in FIG. **5***b* maintains the perceptive effect of the audio being independent of the video rate of display, yet tying the audio content to the video frames being displayed.

[0078] Additionally, the audio of, for example, the sounds of footfalls can further be divided into individual sound packets that are played in bursts at a tempo or pace corresponding to the desired pace without altering the rate or speed of audio. Alternatively, an audio of a series of, for example, footfalls which includes a footfall followed by an interval of silence before a subsequent footfall (and so on) can be alternately speeded up during the intervals of silence only.

[0079] Another variation, shown in FIGS. **1***a-c*, is the output connection of a control signal to the exercise device **12**. The prerecorded video may include coded data for setting the exercise device to predetermined resistance values. In this case, the program would include a control thread which accesses the control data associated with the video frame which sets the resistance. This data would then be translated into setting values which would be transmitted to the servomotor or stepper motor connected to the resistance control such as resistance wheel on the exercise stand.

[0080] The interface unit **132** can be adapted and configured to include a battery, a programmable interrupt controller (PIC) or processor, a biological parameter measurer **144**, such as a heart rate receiver tuned to the transmission frequency of the heart rate transmitter, a series of shift registers, a 10 MegaHertz clock, wheel speed input terminals which mate with the contacts on the exercise machine **12**, and a nine pin output connector which connects the interface unit **132** to a controller keypad **118**. The PIC processor can, for example, be an 8 bit device, which processes the incoming tics, or beats from the wheel speed sensor and the ticks from the output of the heart rate receiver. The shift registers in the interface unit convert the data from the PIC Processor to 32 bit words for compatibility of communication with a player. The interface unit **32** is adapted and configured to collect data from the heart rate and wheel speed inputs and transmits the heart rate and wheel speed data to the player when queried by the main program. Provision may also be included in the interface unit for providing a signal to a stepper motor or servomotor on the exercise device to vary the resistance provided by the resistance roller.

[0081] A logic flow diagram of the embedded program in the PIC processor is shown in FIG. **6***a*. When the user turns on the player activates the playing of a video, the interface unit processor starts in operation **600**. A run time crystal clock (RTCC) is used to run the processor and to measure time durations between input pulses in the PIC processor. This RTCC runs at 10 MHz and counts between zero and 255. The output rolls over at 255. This equates to a rollover time of about a maximum of 2 milliseconds. Operation **602** initializes several flags and registers to zero. Specifically, a load pulse flag, a heart beat flag, a heart tic flag, a wheel rotation flag and a wheel tic flag are set to zero. Also, a heart count register, a heart store register, a wheel count register, and a wheel store register are set to zero. The heart count registers and wheel count registers are used to accumulate time tics between input pulses from the heart rate receiver and the wheel rotation reed switch as will become more apparent below.

[0082] Control then transfers to operation **604** where the run time crystal clock is set to 99. This clock then counts up to 255 and then rolls over to zero and continues counting to 255, rolling over, and repeating. This works out to about 2 milliseconds between rollovers. Control then shifts to operation **606** where the query is made whether the RTCC has rolled over. The actual query is whether the RTCC is less than 90. If yes, the RTCC is reset to 99 in operation **608** and the heart tic and wheel tic flags are set in operation **610**. Control then proceeds to operation **612**. If the RTCC has not yet rolled over, control passes directly to operation **612** without passing through operations **608** and **610**. Operation **612** queries whether a load pulse flag has been set by the control program. This flag will be set if the program is ready to receive input from the interface unit **32**. In this case, control transfers to operation **614** where the interface unit **32** output registers are loaded with the contents of the heart store and wheel store registers. These output registers are then immediately read by the operating system through the connection through a user input interface, such as keypad **118**.

[0083] Whether or not the load pulse flag is set by the player, control then passes to operation **616** where the query is made whether a heartbeat flag has been set, i.e. a beat has been received by the heart rate receiver. If a beat has been received, control passes to operation **618** where the heart count register contents are transferred to the heart store register. Then, in operation **620**, the heart count register is reset to zero and the heart beat flag is reset in order to sense another heartbeat. Control then proceeds from operation **620** to operation **622**. If no heartbeat has been received in the heart rate receiver, and thus the heart beat flag is not set, operation **616** transfers directly to operation **622**.

[0084] In operation **622** using a bicycle, for example, as exercise device **12**, a query is made whether the wheel rotate flag has been set by passage of a wheel magnet past a reed switch. If not, control passes to operation **624**. If the wheel rotate flag is set, control passes to operation **626** where the contents of the wheel count register are moved to the wheel store register. Control then transfers to operation **628**, where the wheel count register is set to zero and the wheel rotate flag is reset in order to sense receipt of another wheel rotation.

[0085] Operation **624** queries whether the heart tic flag is set. If so, control transfers to operation **632** where the heart count register is incremented and the heart tic flag is reset. Control then transfers to operation **630**. If the heart tic flag is not set, operation **624** transfers control directly to operation **630**.

[0086] Operation **630** queries whether the wheel tic flag is set. If so, control transfers to operation **634** where the wheel count register is incremented and the wheel tic flag is reset. Control then passes back to operation **606**. If the wheel tic flag is not set, operation **630** passes directly back to operation **606**.

[0087] The sequence of operations described in FIG. **6***b* is continuous. The net effect of the sequence is to constantly update the heart count, wheel count, heart store, and wheel store registers as wheel rotations and heart beats are received. This information is passed into the output registers for transmission to the control system whenever the control program requests input which is about 60 times per second. It is to be understood that the above description is exemplary of one embodiment only.

[0088] As will be appreciated by this disclosure similar logic can be applied to other exercise devices to achieve similar results.

[0089] Other programmed method variations and equivalents for providing the above exercise device and user input to the playing device will become readily apparent to those skilled in the art. In addition, other playing devices may be utilized in place of the system. For example, an MPEG-2 compatible player coupled to a personal computer may be used, or another CD player using a different operating system such as a Sony video game CD player. In these cases, the hardware in the interface unit may have to be modified to achieve bit compatibility with the particular player input devices. However, the basic logic flow of the example described above could still apply.

[0090] Many of the above methods related to type and characteristic of the audio footfall file played back also apply in this type of implementation.

IV. Examples

[0091] Example 1

[0092] In one example, the pace of the video stream changes with the pace of the footsteps which corresponds to the rate at which a user is exercising as described above. The rate of the correlated audio can be set-up to increase as a user increases the speed at which the user performs. Thus, the pace of the video, i.e., the rate at which the video is streamed to the screen, correlates to the pace of, for example, the footsteps or the rate at which a user is cycling on a stationary bike. It has been observed that, for example, runners may find the urge to synchronize their steps to a strong musical beat or to a repetitive sound, such as a footfall. Similarly, cyclists may be urged to press down on the pedal at a rate corresponding to a repetitive sound. This urge may motivate the exerciser to perform at the video correlated pace as the speed of the video and the correlated audio increases to correspond to the rate at which the viewing would change if, for example, a runner were running at a particular pace and his or her footfalls were at a particular pace. The rate of change of each of the audio tracks is accomplished such that the sounds continue to sound natural but achieves the effect of a Foley artist in making the various audio tracks to correspond to a video.

[0093] Example 2

[0094] In another example, the pace of exercise interactively changes with the pace of the footsteps. The pace of the video, i.e., the rate at which the video is streamed, can change in response to a measured biological parameter. A measured parameter may be used to provide feedback that a user should increase his or her speed or decrease his or her speed (e.g., if heart rates are above or below desired levels, the correlated audio can be increased, along with the speed of the machine to increase the heart rate to a desired or target level).

[0095] Example 3

[0096] In another example, a user could select a difficulty level and/or or other parameters that would result in a certain speed of footsteps being played. This could be a combination of several parameters, such as in the case where a person might enter their height and a difficulty level of "5". The program might know that "5" for a tall person is a different foot pace then "5" for a short person.

[0097] Example 4

[0098] In another example, to the extent that there was ambient noise (e.g., water running, leaves falling, wind blowing) or music that audio would remain at a natural rate (e.g., the rate that it would be heard by the user in nature at) regardless of speed of video or the correlated audio, but the sound for footfalls or any other video correlated sound that corresponds to a user's actual activity would change with the pace of video scenery.

[0099] Example 5

[0100] In another example, a user can select a competition rate wherein, for example, the user performs at a base rate to establish his or her normal training rate. Then, the user can select a pre-defined competitor profile, or a rate of performance improvement, e.g., 10%. In this scenario, the correlated sound will occur at the rate of the competitor profile or the rate of performance improvement while the video can stream at the rate at which the user is actually performing or at the rate of the chosen competitor profile or performance rate improvement.

[0101] Example 6

[0102] In another example of a deployment system for the methods of the invention, a data processing system for administering course material is provided comprising a computer or server as shown in FIG. 1B. The computer can, if desired, be connected to a network of remote stations as shown in FIG. 1C. In operation, the remote stations could then serve as the data entry points for information to be gathered, for example at a remote class site or by a participant registering for a class on-line. Information gathered includes, for example, information about the materials to be presented, the participant, the environment, etc. The remote stations can also serve as access points through which people transmit inquiries concerning the materials presented or exercise programs and for responding to those inquiries. Additionally, each station can store a record of each participant's details, including performance information for each class, and periodically send this information to the central computer for processing.

[0103] Additionally, it will be appreciated that the exercise can be administered in the form of interval training As will be appreciated by those skilled in the art, the ordering of these steps, or any steps described herein, can occur as illustrated in the various figures, or can occur in any other order that achieves the objectives of the invention without departing from the scope of the invention.

[0104] In another embodiment of the invention, the system and method can be adapted to work in conjunction with the invention disclosed in U.S. Pat. No. 6,142,913 for "Dynamic Real Time Exercise Video Apparatus and Method" (Ewert). Thus the system can be adapted to incorporate varying video playback rate adjusts the frame rate of motion video content being replayed on a display device based on the intensity at which a participant exerts themselves. This system supports the illusion that the participant is actually traveling through the terrain being displayed. A result of the use of this system is that a participant who exercises at a higher intensity will view more footage than will a participant who exercises at a lower intensity, as the frame rate speed will be higher and more frames of the footage will be viewed.

[0105] An additional benefit of the systems and methods disclosed herein is the modularity of the systems and methods.

[0106] While preferred embodiments of the present invention are shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now occur to those skilled in the art without departing from the invention. It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is intended that the claims following the description define the scope of the invention and that methods and structures within the scope of these claims and equivalents are covered thereby.

What is claimed is:

1. An exercise system comprising:

a video playing device in communication with a central processing unit and a user input interface connected thereto adapted and configured to receive one or more inputs from a user and transmit the one or more inputs to the central processing unit;

a video frame sequence encoded onto a storage medium in communication with and playable on the video playing device;

a video monitor in communication with the video playing device for displaying the video frame sequence reproduced by the video playing device;

a video frame rate controller configured to vary a rate of display of sequential frames in the video frame sequence reproduced by the video playing device on the video monitor in response to the one or more inputs from the user;

one or more audio rate controllers configured to vary a rate of delivery of two or more audio files on an audio playing device in response to the one or more inputs from the user; and

an exercise device.

2. The system of claim **1** wherein the video frame rate controller comprises a computer program stored on a storage medium with the prerecorded video frame sequence, the program being operable with the central processing unit in the video playing device when the video sequence is played to modify the frame display rate in response to the signal from a user interface rate detector.

3. The system of claim **2** wherein the signal from the user interface rate detector is one or more of a biological parameter measurer, and an exercise device operation detector.

4. The system of claim **3** wherein the user interface rate detector is a heart rate signal receiver for receiving a signal from a transmitter worn by the user controlling the rate at which the video is displayed on the video monitor.

5. The system of claim **1** wherein the audio rate controller comprises a computer program stored on a storage medium with an audio sequence, the program being operable with the central processing unit in the audio playing device when the audio sequence is played to modify the audio delivery rate in response to the signal from the user interface rate detector.

6. The system of claim **5** wherein the signal from the user interface rate detector is one or more of a biological parameter measurer, and an exercise device operation detector.

7. The system of claim **6** wherein the interface rate detector is a heart rate signal receiver for receiving a signal from a transmitter worn by the user and generating a signal usable by the video player for displaying a user's heart rate on the display.

8. The system of claim **1** wherein the user input is one or more of each of manual input and automatic input.

9. The system of claim **8** wherein the manual input is one or more of height, weight, age, difficulty level, target training rate, target heart rate, and target activity level.

10. The system of claim **8** wherein the automatic input is a signal from one or more of a biological parameter measurer, and an exercise device operation detector.

11. The system of claim **1** wherein the exercise device is selected from the group comprising a bicycle, a stair stepper, and an elliptical trainer.

12. The system of claim **1** wherein the rate of delivery of the two or more audio files are delivered asynchronous to each other.

13. The system of claim **1** wherein each of the recorded video frame sequences includes a frame time stamp and the video frame rate controller is adapted to generate a variable time adjustment factor in proportion to the one or more inputs from the user and a adjustor adapted to apply a factor to the frame time stamp to determine a modified time at which the next video frame sequence is to be displayed.

13. An apparatus for engaging a user of an exercise device interactively in viewing a video frame sequence of an activity on a video monitor comprising:

a video player in communication with the video monitor adapted and configured to play a video frame sequence on the video monitor;

a detector adapted and configured to detect a rate of exercise by the user on the exercise apparatus and transmit a signal proportional to the rate of exercise;

a video controller in communication with the video player adapted and configured to receive the signal proportional to the rate of exercise and transmit a signal generated in response to the signal proportional to the rate of exercise to the video player wherein the video player adjusts the rate at which the video frame sequence is displayed;

two or more audio controllers in communication with an audio player adapted and configured to receive the signal proportional to the rate of exercise and transmit one or more signals generated in response to the signal proportional to the rate of exercise to the audio player wherein the audio player adjusts the rate at which the audio is played.

14. The apparatus according to claim **13** wherein the exercise device is selected from the group comprising a bicycle, a stair stepper and an elliptical trainer.

15. The apparatus according to claim **13** wherein the signal from the user interface rate detector is one or more of a biological parameter measurer, and an exercise device detector.

16. The apparatus according to claim **15** wherein the interface rate detector is a heart rate signal receiver for receiving a signal from a transmitter worn by the user and generating a signal usable by the video player for displaying a user's heart rate on the display.

17. A method of controlling a video frame sequence display rate of a video playback sequence in a device in response to an external signal comprising the steps of:

(a) accessing a duration time stamp for a current video frame;

(b) determining from the external signal an adjustment value for changing the display rate (c) obtaining a modified duration time to a next frame by adding the adjustment value to the duration time stamp;

(d) displaying the next frame when the modified duration time has passed;

(e) accessing a duration time stamp for a current audio data packet;

(f) determining from the external signal an adjustment value for changing the rate of delivery of the audio data packet;

(g) obtaining a modified duration time to a next audio frame by adding the adjustment value to the duration time stamp; and

(h) playing the next audio data packet when the modified duration time has passed.

18. The method of claim **17** further comprising the step of repeating steps (a) through (d) for each subsequent video frame and steps (e) through (h) for each subsequent audio data packet.

19. The method of claim **17** wherein the accessing step (a) further comprises the steps of:

i) setting a time offset to current clock time;

ii) displaying a current video frame; and

iii) accessing a frame time stamp and a duration time stamp for the current video frame.

20. The method of claim **19** wherein the step of determining further comprises the step of comparing the external signal to predetermined criteria to determine the adjustment value.

21. The method of claim **20** wherein the external signal is a user variable exercise rate signal.

22. The method of claim **20** wherein the step of displaying (d) further comprises the steps of:

i) adding the modified duration value to the time offset to obtain a next frame time; and

ii) displaying the next frame when clock time exceeds the next frame time.

23. The method of claim **17** wherein the accessing step (e) further comprises the steps of:

i) setting a time offset to current clock time;

ii) playing a current audio data packet; and

iii) accessing a frame time stamp and a duration time stamp for the current audio data packet.

24. The method of claim **23** wherein the step of determining (f) further comprises the step of comparing the external signal to predetermined criteria to determine the adjustment value.

25. The method of claim **24** wherein the external signal is a user variable exercise rate signal.

26. The method of claim **23** wherein the step of playing (h) further comprises the steps of:

i) adding the modified duration value to the time offset to obtain a next audio data packet time; and

ii) playing the next audio data packet when clock time exceeds the next frame time.

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