(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) **International Patent Classification**[7]: **G01D 21/00**, A61B 5/22, G06F 17/40, A63B 71/06

(21) **International Application Number:**
PCT/FI2004/000574

(22) **International Filing Date:** 1 October 2004 (01.10.2004)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**
20031423   1 October 2003 (01.10.2003)   FI

(71) **Applicant** *(for all designated States except US)*: **FRWD TECHNOLOGIES LTD** [FI/FI]; Kiviharjuntie 11, FI-90220 Oulu (FI).

(72) **Inventors; and**
(75) **Inventors/Applicants** *(for US only)*: **MOILANEN, Hannu** [FI/FI]; Leppiojankuja 6 A 3, FI-90800 Oulu (FI). **KAMPMAN, Ville** [FI/FI]; Rautatienkatu 5 A 15, FI-90100 Oulu (FI). **SALOVAARA, Arttu** [FI/FI]; Puurahakatu 2 C 46, FI-20100 Turku (FI).

(74) **Agent: PAPULA OY**; P.O. Box 981 (Fredrikinkatu 61A), FI-00101 Helsinki (FI).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** METHOD AND COMPUTER PROGRAM FOR RECONSTRUCTING AT LEAST ONE ACTIVITY
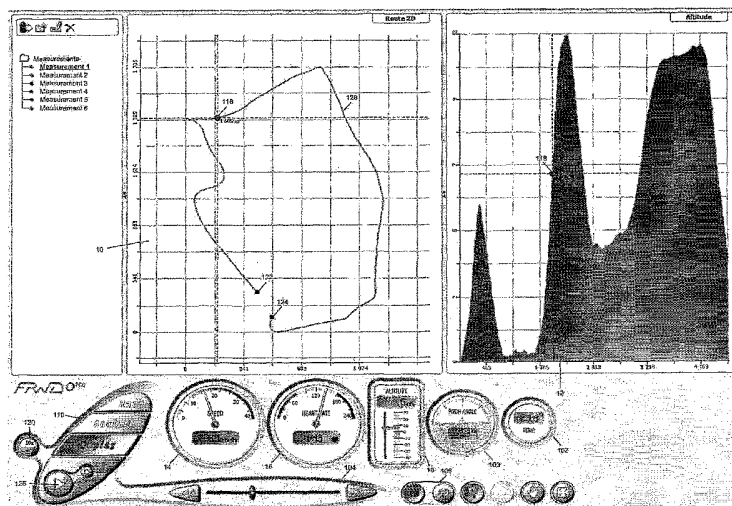
(57) **Abstract:** The present invention discloses a method and a computer program for reconstructing at least one activity recorded using a measurement device. Measurement data relating to at least one continuous activity is loaded into a memory, the measurement data including at least a plurality of consecutive measurement point sets, each set including at least one heart rate measurement, a time stamp, a GPS position measurement and an altitude measurement. Furthermore, the activity is reconstructed based on the loaded measurement data and displayed continuously at a desired playback speed using a plurality of graphs illustrating various values. The values may include one or more of the following: a two or three-dimensional position, a pitch angle value, a speed value, a heart rate value, an altitude value, and a pitch angle value, speed value, heart rate value and/or altitude value as a function of time or distance.

METHOD AND COMPUTER PROGRAM FOR RECONSTRUCTING AT LEAST ONE ACTIVITY

FIELD OF THE INVENTION

The present invention relates partly to position determining. In particular, the present invention relates to a novel and improved method and computer program product for reconstructing at least one activity, e.g. a sport activity, measured using a measuring device.

BACKGROUND OF THE INVENTION

People have always been interested in how they perform in various tasks, e.g. in various sport events. Different manufacturers have provided various kinds of devices that can be used to analyze e.g. a sport event. These devices include e.g. a heart rate monitor, a wrist computer etc.

Global Positioning System (GPS) provides a service in which by using a special GPS receiver position information can be acquired. The GPS uses a plurality of satellites to determine the position.

There exists a plurality of known solutions that use the GPS to log a path e.g. of a sport event. Such a data logger can be afterwards connected to a computer and the performed path, e.g. a run path, can be displayed on a screen of the computer by connecting the logged position points (coordinates). Furthermore, there exist known solutions that are able to log e.g. heart rate during an exercise.

One known solution uses a combination of a wristwatch and a heart rate belt display and/or record the heart rate data. The watch can be connected to a computer after the exercise, and based on the recorded heart rate data, a heart rate curve can be displayed to the user as a function of time.

2

What the prior art solutions do not provide is how to reconstruct and display the recorded activity, event or exercise based on the recorded data in the most conventient and illustrative way.

SUMMARY OF THE INVENTION

According to one aspect of the invention, there is provided a method for reconstructing at least one activity recorded using a measurement device, the method comprising the steps of loading measurement data relating to at least one continuous activity into a memory, the measurement data including at least a plurality of consecutive measurement point sets, each set including at least one heart rate measurement, a time stamp, a GPS position measurement and an altitude measurement; reconstructing the activity based on the loaded measurement data; and providing a continuous activity playback on a computer screen at a desired playback speed using a plurality of graphs illustrating various values relating to said activity.

In one embodiment the method further comprises the steps of loading measurement data relating to at least two different continuous activities recorded essentially in the same path into the memory, the measurement data including at least a plurality of consecutive measurement point sets, each set including at least one heart rate measurement, a time stamp, a GPS position measurement and an altitude measurement; reconstructing the activities based on the loaded measurement data; and providing at least two continuous activity playbacks on the computer screen simultaneously at a desired playback speed using a plurality of graphs illustrating various values relating to said activities.

In one embodiment the method further comprises providing at least one continuous activity playback on the computer screen at a virtual three-

3

dimensional landscape created based on the loaded measurement data.

In one embodiment abovementioned various values comprise at least one of a two and/or three-
5   dimensional position, a pitch angle value, a speed value, a heart rate value, an altitude value, and a pitch angle value, speed value, heart rate value and/or alitude value as a function of time or distance.

10   In one embodiment the method further comprises determining differences between each reconstructed activity as a function of time at a desired moment of time; and displaying the differences.

In one embodiment the method further com-
15   prises changing the desired playback speed for each playback and/or during a playback.

According to another aspect of the invention, there is provided a computer program for reconstructing at least one activity recorded using a measurement
20   device, the computer program product comprising program code adapted to perform the steps of loading measurement data relating to at least one continuous activity into a memory, the measurement data including at least a plurality of consecutive measurement point
25   sets, each set including at least one heart rate measurement, a time stamp, a GPS position measurement and an altitude measurement; reconstructing the activity based on the loaded measurement data; and providing a continuous activity playback on a computer screen at a
30   desired playback speed using a plurality of graphs illustrating various values relating to said activity.

In one embodiment the computer program further comprises program code adapted to perform the steps of loading measurement data relating to at least
35   two different continuous activities in the same path into the memory, the measurement data including at least a plurality of consecutive measurement point

sets, each set including at least one heart rate meas-
urement, a time stamp, a GPS position measurement and
an altitude measurement; reconstructing the activities
based on the loaded measurement data; and providing at
5   least two continuous activity playbacks on the com-
puter screen simultaneously at a desired playback
speed using a plurality of graphs illustrating various
values.

In one embodiment the computer program fur-
10   ther comprises program code adapted to perform the
step of providing at least one continuous activity
playback on the computer screen at a virtual three-
dimensional landscape created based on the loaded
measurement data.

15   In one embodiment the graphs comprise at
least one of a two and/or three-dimensional position,
a pitch angle value, a speed value, a heart rate
value, altitude value, and a pitch angle value, speed
value, heart rate value and/or alitude value as a
20   function of time or distance.

In one embodiment the computer program fur-
ther comprises program code adapted to perform the
steps of determining differences between each recon-
structed activity as a function of time at a desired
25   moment of time; and displaying the differences.

In one embodiment the computer program fur-
ther comprises program code adapted to perform the
step of changing the desired playback speed for each
playback and/or during a playback.

30   In one embodiment the computer program has
bee arranged on a storage medium.

The present invention has several advantages
over the prior-art solutions. With the present inven-
tion a user is able to accurately and in an illustra-
35   tive way to replay an activity or exercise. Further-
more, a user is able to arrange a comparision or com-

5

petition between several different measurements (ac-
tivities).

BRIEF DESCRIPTION OF THE DRAWINGS

5   The accompanying drawings, which are included
to provide a further understanding of the invention
and constitute a part of this specification, illus-
trate embodiments of the invention and together with
the description help to explain the principles of the
10   invention. In the drawings:
       Figure 1 illustrates one embodiment of a pos-
sible snapshot of a window in accordance with the pre-
sent invention;
       Figure 2 illustrates another embodiment of a
15   possible snapshot of a window in accordance with the
present invention; and
       Figure 3 illustrates a virtual three-
dimensional animation mode in accordance with the pre-
sent invention.
20

DETAILED DESCRIPTION OF THE INVENTION

       Reference will now be made in detail to the
embodiments of the present invention, examples of
which are illustrated in the accompanying drawings.
25   Figure 1 illustrates one embodiment of a pos-
sible snapshot of a window in accordance with the pre-
sent invention.
       The illustrated window is a graphical user
interface of a software program that can be used to
30   reconstruct a measured event, e.g. a sport event.
       The measurement data needed to reconstruct an
exercise can be obtained e.g. directly from a measure-
ment device (downloading) or from a measurement file
downloaded earlier to the computer. In this embodiment
35   the measurement file includes a plurality of consecu-
tive measurement point sets. Each set includes at

6

least one heart rate measurement, a time stamp, a GPS
position measurement and an altitude measurement.

Figure 1 comprises two main graphs 10 and 12.
The first graph 10 is a scaled map into which an exer-
5   cise is plotted. The curve is plotted based on the GPS
position measurements recorded with the measurement
device. The second graph 12 illustrates altitude as a
function of distance. In another embodiment altitude
may be illustrated as a function of time.

10   Figure 1 displays the program in a replay
mode. In the replay mode, an exercise can be replayed
at a desired playback speed. The playback speed is cho-
sen using button 120, and the speed can be adjusted
during a replay of a measurement. When a measurement is
15   to be replayed, the replaying sequence starts from a
starting point 122. When a play button 126 is pressed
the playback is started, and indicator 116 moves along
a measured path 128 according to the chosen playback
speed. At the same time an indicator 118 moves along
20   the altitude profile in graph 12 according to the cho-
sen playback speed.

There are further indicators that illustrate
the exercise in a continuous manner. A meter 14 shows
the current speed, a meter 16 the current heart rate, a
25   meter 18 the current altitude, a meter 100 the current
pitch angle and a meter 102 the current temperature. It
must be noted that each meter is directly linked to the
played back exercise. When indicators 116 and 118 move
from one measured point to the next point, meters 14,
30   16, 18, 100 and 102 show the corresponding value on the
next point. Thus a continuous and illustrative playback
of the exercise is achieved.

A slide control 104 can be used to find a de-
sired point in the exercise when the playback is in a
35   halted state. Buttons 106 can be used to choose between
a two-dimensional and a three-dimensional display mode
in graph 10.

7

Also highlights of the activity may be pre-
sented on a computer screen on the special way. For
example, when activity top speed is achieved, the re-
play may be automatically paused and a custom anima-
5   tion may be displayed to indicate the event.

Figure 2 illustrates another embodiment of a
possible snapshot of a window in accordance with the
present invention.

The illustrated window is a graphical user
10   interface of a software program that can be used to
reconstruct a measured event, e.g. a sport event.

The measurement data needed to reconstruct an
exercise can be obtained e.g. directly from a measure-
ment device (downloading) or from a measurement file
15   downloaded earlier to the computer. In this embodiment
the measurement file includes a plurality of consecu-
tive measurement point sets. Each set includes at
least one heart rate measurement, a time stamp, a GPS
position measurement and an altitude measurement.

20   Figure 2 comprises two main graphs 20 and 22.
The first graph 20 is a scaled map into which several
exercises are plotted. The curves are plotted based on
GPS position measurements logged with a measurement
device. The second graph 22 illustrates altitude as a
25   function of distance. In another embodiment altitude
may be illustrated as a function of time.

Figure 2 displays the program in a race mode.
In the race mode, several exercises recorded at the
same exercise path can be replayed at the same time at
30   a desired playback speed. The playback speed is chosen
using a button 218, and the speed can be adjusted dur-
ing a replay of a measurement. The participants (dif-
ferent measurements) can be chosen using open buttons
in a menu 28. When the measurements are to be replayed,
35   the replaying sequence starts from a starting point
212. When a play button 216 is pressed the playback is
started and indicators 220 move along measured paths

8

222 according to the chosen playback speed. At the same time indicators 224 move along the altitude profile in graph 22 again according to the chosen playback speed.

5   There are further indicators that illustrate the measurements in a continuous manner. A meter 24 shows the current speeds of the competitors using separate speed indicators, and a meter 26 shows the current heart rates of the competitors (measurements) using separate speed indicators. It must be noted that each

10   meter is directly linked to the played back exercises. When indicators 220 and 224 move from one measured point to the next point, meters 24 and 26 show the corresponding values of the next point. Thus a continuous and illustrative playback of the exercises is achieved.

15   A slide control 202 can be used to find a desired position of the competitors at a desired time in the exercise when the playback is in a halted state. A button 204 can be used to zoom either of the graphs 20, 22.

20   Figure 2 further comprises a checkpoint window 26. When the update button is pressed, the software determines differences between each competitor (measurement) relative to the leader and displays the time difference between the competitors (measurements).

25   Figure 3 illustrates a virtual three-dimensional animation mode in accordance with the present invention. Due to the fact that the environmental and physiological data is gathered and combined, the activity replay may be presented also in virtual

30   three-dimensional animation mode as well as in mathematical graphs. In the three-dimensional virtual animation mode, the activity is visualized for the operator like the typical animated three-dimensional computer game. By using accurate barometrical altitude

35   measurement data combined with the GPS xy-location data, the three-dimensional virtual mode altitude graphs of the landscape may be created by using a spe-

9

cial interpolation mathematical algorithm. Actual re-
play of the activity is then presented on the created
virtual landscape. During the replay, the virtual ath-
lete performs the activity according to the collected
5   physiological, environmental and GPS data. The col-
lected data may also be presented as numerical values
on the screen during the replay. In addition, when for
example the virtual runner's heart rate increases on
the uphill, the replay presents these changes by modi-
10   fying also the virtual runner's breath inhale speed
and appearance of the virtual face. Furthermore, when
for example the speed increases, the virtual runner
accelerates his/her speed according to the data
changes. The three-dimensional virtual replay may also
15   be played at various speeds and even backwards.

In one embodiment, the computer operator may
change the camera view during replay. Different camera
views comprise, for example, a helicopter view, a sta-
ble or a moving tv-camera view or an athlete's view.
20   Also, if there are more athletes on the replay at the
same time, camera views may be changed from one ath-
lete to another.

The aforementioned steps and embodiments in
one embodiment are implemented using a computer pro-
25   gram that may be loaded into the memory of a computer
or used directly from a storage medium, e.g. a compact
disc.

It is obvious to a person skilled in the art
that with the advancement of technology, the basic
30   idea of the invention may be implemented in various
ways. The invention and its embodiments are thus not
limited to the examples described above, instead they
may vary within the scope of the claims.

10

CLAIMS

1. A method for reconstructing at least one activity recorded using a measurement device,

characterised in that the method
5   comprises:

loading measurement data relating to at least one continuous activity into a memory, the measurement data including at least a plurality of consecutive measurement point sets, each set including at least
10   one heart rate measurement, a time stamp, a GPS position measurement and an altitude measurement;

reconstructing said activity based on said loaded measurement data; and

providing a continuous activity playback on a com-
15   puter screen at a desired playback speed using a plurality of graphs illustrating various values relating to said activity.

2. The method according to claim 1, characterised in that the method further comprises:
20   loading measurement data relating to at least two different continuous activities recorded essentially in the same path into said memory, the measurement data including at least a plurality of consecutive measurement point sets, each set including at least
25   one heart rate measurement, a time stamp, a GPS position measurement and an altitude measurement;

reconstructing said activities based on said loaded measurement data; and

providing at least two continuous activity play-
30   backs on the computer screen simultaneously at a desired playback speed using a plurality of graphs illustrating various values relating to said activities.

3. The method according to claim 1 or 2, characterised in that providing at least one
35   continuous activity playback on the computer screen at a virtual three-dimensional landscape created based on the loaded measurement data.

11

     4. The method according to claim 1 or 2, characterised in that said various values comprise at least one of the following:

     a two and/or three-dimensional position;

5   a pitch angle value;

     a speed value;

     a heart rate value;

     an altitude value; and

     a pitch angle value, speed value, heart rate value

10   and/or alitude value as a function of time or distance.

     5. The method according to claim 2, characterised in that the method further comprises:

     determining differences between each reconstructed

15   activity as a function of time at a desired moment of time; and

     displaying said differences.

     6. The method according to claim 1, 2, 3, 4 or 5, characterised in that the method fur-

20   ther comprises:

     changing the desired playback speed for each playback and/or during a playback.

     7. A computer program for reconstructing at least one activity recorded using a measurement de-

25   vice,

     characterised in that the computer program comprises program code adapted to perform the steps of:

     loading measurement data relating to at least one

30   continuous activity into a memory, the measurement data including at least a plurality of consecutive measurement point sets, each set including at least one heart rate measurement, a time stamp, a GPS position measurement and an altitude measurement;

35   reconstructing said activity based on said loaded measurement data; and

12

providing a continuous activity playback on a computer screen at a desired playback speed using a plurality of graphs illustrating various values relating to said activity.

5   8. The computer program according to claim 7, c h a r a c t e r i s e d   in the computer program further comprises program code adapted to perform the steps of:

loading measurement data relating to at least two
10 different continuous activities recorded essentially in the same path into said memory, the measurement data including at least a plurality of consecutive measurement point sets, each set including at least one heart rate measurement, a time stamp, a GPS posi-
15 tion measurement and an altitude measurement;

reconstructing said activities based on said loaded measurement data; and

providing at least two continuous activity playbacks on the computer screen simultaneously at a de-
20 sired playback speed using a plurality of graphs illustrating various values relating to said activities.

9. The computer program according to claim 7 or 8, c h a r a c t e r i s e d   in the computer program further comprises program code adapted to perform the
25 step of:

providing at least one continuous activity playback on the computer screen at a virtual three-dimensional landscape created based on the loaded measurement data.

30   10. The computer program according to claim 7, 8 or 9, c h a r a c t e r i s e d   in that said graphs comprise at least one of the following:

a two and/or three-dimensional position;

a pitch angle value;
35   a speed value;

a heart rate value;

an altitude value; and

13

a pitch angle value, speed value, heart rate value and/or alitude value as a function of time or distance.

11. The computer program according to claim 5   8, c h a r a c t e r i s e d   in that the computer program further comprises program code adapted to perform the steps of:

determining differences between each reconstructed as a function of time activity at a desired moment of 10   time; and

displaying said differences.

12. The computer program according to claim 7, 8, 9, 10 or 11, c h a r a c t e r i s e d   in that in the computer program further comprises program code 15   adapted to perform the step of:

changing the desired playback speed for each playback and/or during a playback.

13. The computer program according to claim 7, 8, 9, 10, 11 or 12, c h a r a c t e r i s e d   in that 20   the computer program has been arranged on a storage medium.
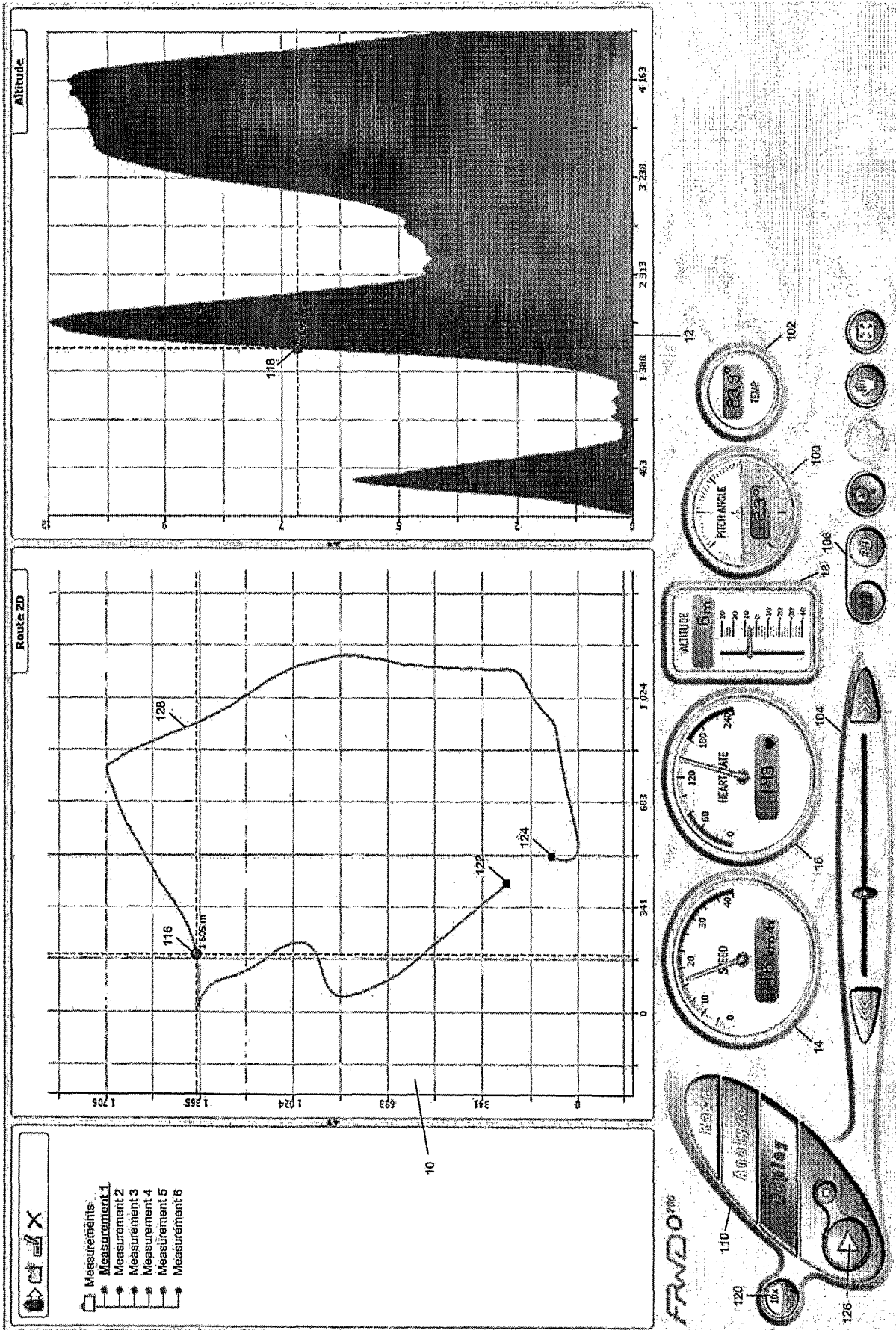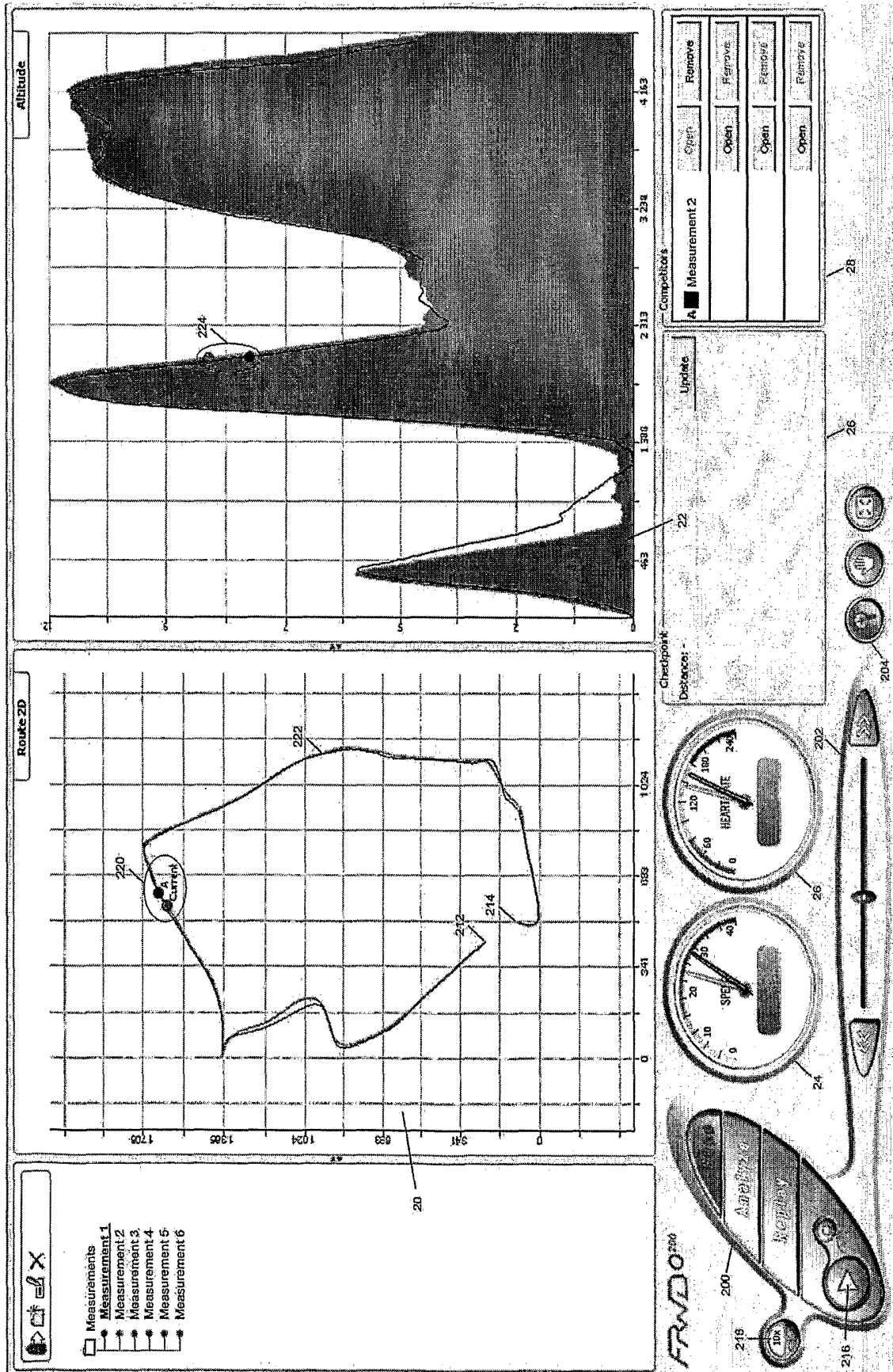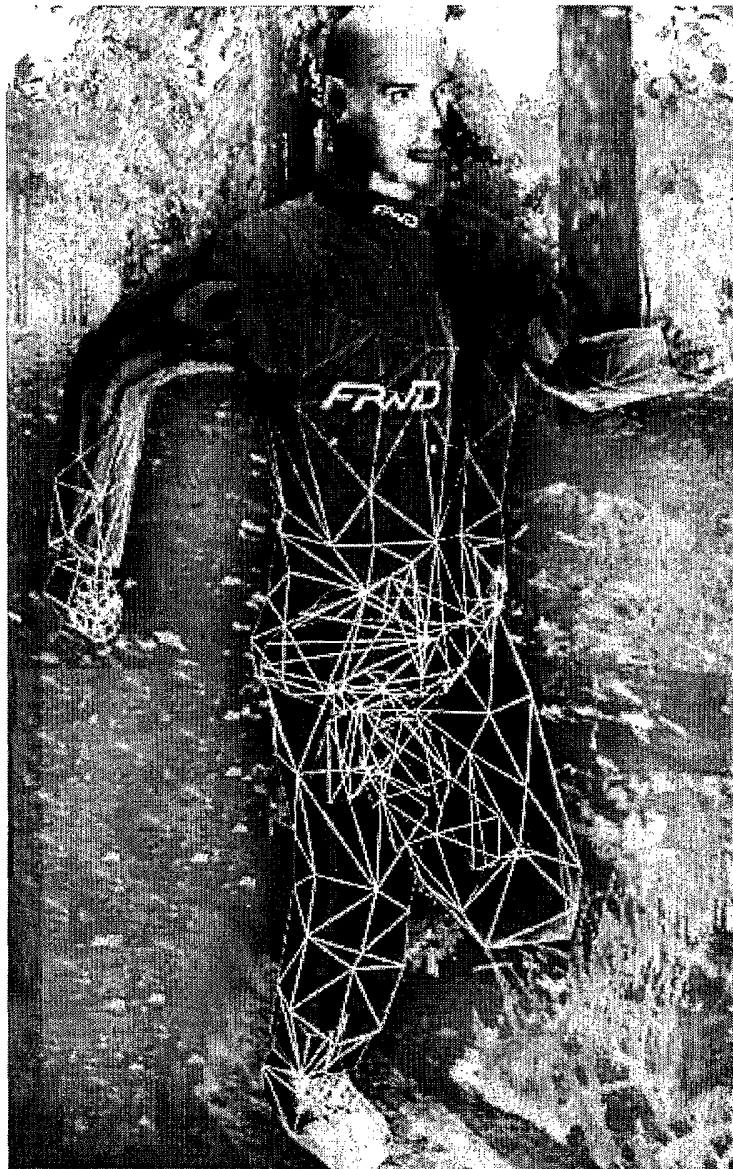
Fig. 1

Fig. 2

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 2004/000574

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G01D 21/00, A61B 5/22, G06F 17/40, A63B 71/06

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: G01D, A61B, G01B, A63B, G06F

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

SE,DK,FI,NO classes as above

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

EPO-INTERNAL,WPI DATA, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6002982 A (FRY, W R), 14 December 1999 (14.12.1999), column 2, line 37 - column 3, line 22; column 5, line 12 - line 25, figure 4, claims 1-13, abstract	1-13
X	US 6013007 A (ROOT, G M ET AL), 11 January 2000 (11.01.2000), column 2, line 2 - column 3, line 12; column 5, line 66 - column 6, line 11, figure 7, abstract	1-13
X	WO 0141879 A1 (SHANDOR MOTION SYSTEMS), 14 June 2001 (14.06.2001), page 2, line 9 - page 4, line 7; page 17, line 17 - page 18, line 19, abstract	1-13

| [X] Further documents are listed in the continuation of Box C. | [X] See patent family annex. |

Date of the actual completion of the international search	Date of mailing of the international search report
14 January 2005	17 -01- 2005

Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Gordana Ninkovic /LR Telephone No. + 46 8 782 25 00

Form PCT/ISA/210 (second sheet) (January 2004)

C (Continuation).   DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CA 2305633 A1 (PLAMONDON, G), 25 October 2001 (25.10.2001), the whole document	1-13
	--	
A	WO 0239363 A1 (GP-SPORTS SYTEMS PTY LTD), 16 May 2002 (16.05.2002), abstract	1-13
	--	
A	US 6198431 B1 (GIBSON, J G), 6 March 2001 (06.03.2001), abstract	1-13
	--	
A	WO 9854581 A3 (PHATRAT TECHNOLOGY, INC), 3 December 1998 (03.12.1998), abstract	1-13
	--	

US	6002982	A	14/12/1999	US	6148262	A	14/11/2000
				US	6463385	B	08/10/2002
US	6013007	A	11/01/2000	AT	277339	T	15/10/2004
				AU	742130	B	20/12/2001
				AU	3353299	A	18/10/1999
				CA	2323492	A	30/09/1999
				DE	69920438	D	00/00/0000
				EP	1076806	A,B	21/02/2001
				JP	2002507734	T	12/03/2002
				WO	9949279	A	30/09/1999
WO	0141879	A1	14/06/2001	AU	2065301	A	18/06/2001
CA	2305633	A1	25/10/2001	NONE			
WO	0239363	A1	16/05/2002	AU	738702	A,B	27/09/2001
				AU	1479602	A	21/05/2002
				AU	PR133800	D	00/00/0000
US	6198431	B1	06/03/2001	AU	8072398	A	04/01/1999
				CA	2294194	A	23/12/1998
				DE	19882566	T	03/08/2000
WO	9854581	A3	03/12/1998	AU	8055298	A	30/12/1998
				CA	2291701	A	03/12/1998
				EP	1007975	A	14/06/2000
				US	6539336	B	25/03/2003
				US	20020116147	A	22/08/2002
				US	20030093248	A	15/05/2003
				US	20040225467	A	11/11/2004
				US	6266623	B	24/07/2001
				US	6498994	B	24/12/2002
				US	20010037179	A	01/11/2001
				US	20030014210	A	16/01/2003