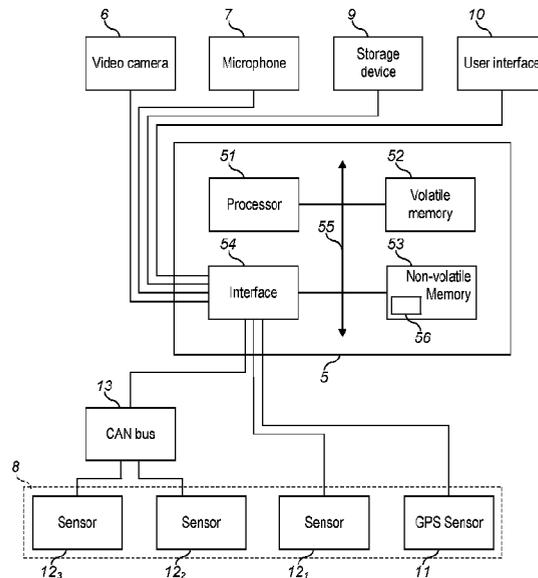




(86) Date de dépôt PCT/PCT Filing Date: 2014/12/05  
 (87) Date publication PCT/PCT Publication Date: 2015/06/11  
 (45) Date de délivrance/Issue Date: 2022/04/26  
 (85) Entrée phase nationale/National Entry: 2016/06/06  
 (86) N° demande PCT/PCT Application No.: GB 2014/053629  
 (87) N° publication PCT/PCT Publication No.: 2015/082941  
 (30) Priorités/Priorities: 2013/12/06 (GB1321626.2);  
 2014/01/05 (GB1400110.1)

(51) Cl.Int./Int.Cl. *G07C 5/08* (2006.01)  
 (72) Inventeurs/Inventors:  
 MCNALLY, LUKE, GB;  
 ROBERTS, MELFYN, GB;  
 TAYLOR, MARK, GB  
 (73) Propriétaire/Owner:  
 COSWORTH GROUP HOLDINGS LIMITED, GB  
 (74) Agent: NORTON ROSE FULBRIGHT CANADA  
 LLP/S.E.N.C.R.L., S.R.L.

(54) Titre : TRAITEMENT DE DONNEES VIDEO ET DE DONNEES DE DETECTION ASSOCIEES A UN VEHICULE  
 (54) Title: PROCESSING VIDEO AND SENSOR DATA ASSOCIATED WITH A VEHICLE



(57) **Abrégé/Abstract:**

Processing video and sensor data associated with a vehicle Apparatus (5) is configured to: obtain first data corresponding to video data from a video camera(6) associated with a vehicle; obtain second data corresponding to sensor data from one or more sensors (8) associated with the vehicle;forma data structure including metadata and the first and second data, wherein first timing information for the first data is included in the metadata and second timing information for the second data is included in the second data, wherein the first and second timing information enable the first and second data to be temporally related.

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

(19) World Intellectual Property Organization  
International Bureau

(43) International Publication Date  
11 June 2015 (11.06.2015)



(10) International Publication Number  
**WO 2015/082941 A3**

- (51) International Patent Classification:  
*G07C 5/08* (2006.01)
- (21) International Application Number:  
PCT/GB2014/053629
- (22) International Filing Date:  
5 December 2014 (05.12.2014)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
1321626.2 6 December 2013 (06.12.2013) GB  
1400110.1 5 January 2014 (05.01.2014) GB
- (71) Applicant: **COSWORTH GROUP HOLDINGS LIMITED** [GB/GB]; The Octagon, St James Mill road, Northampton, Northamptonshire, NN5 5RA (GB).
- (72) Inventors: **MCNALLY, Luke**; C/O Cosworth Group Holdings Limited, The Octagon St. James Mill Road, Northampton, Northamptonshire, NN5 5RA (GB). **ROBERTS, Melfyn**; C/O Cosworth Group Holdings Limited,

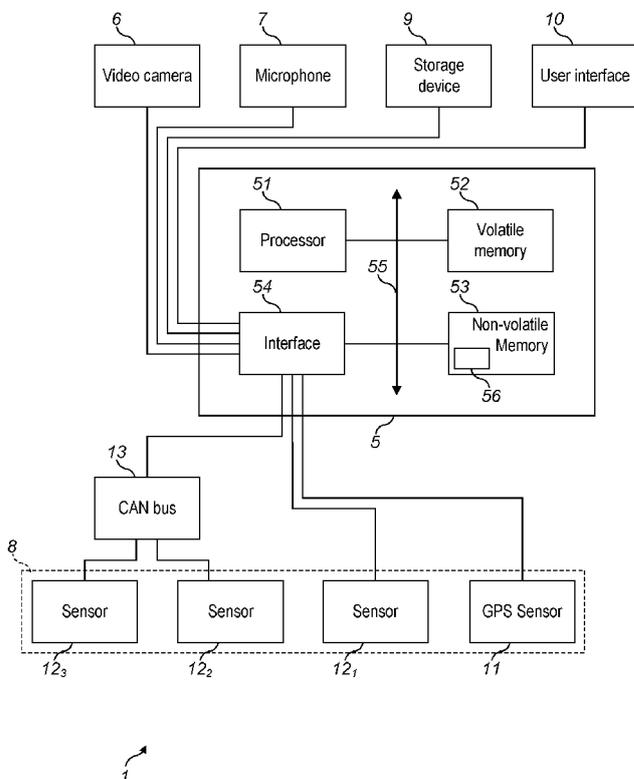
The Octagon St. James Mill Road, Northampton, Northamptonshire, NN5 5RA (GB). **TAYLOR, Mark**; C/O Cosworth Group Holdings Limited, The Octagon St. James Mill Road, Northampton, Northamptonshire, NN5 5RA (GB).

(74) Agent: **TAYLOR, David M.J.**; Stratagem Intellectual Property, Management Limited, Meridan Court, Comberton Road, Toft, Cambridge Cambridgeshire CB23 2RY (GB).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

[Continued on next page]

(54) Title: PROCESSING VIDEO AND SENSOR DATA ASSOCIATED WITH A VEHICLE



(57) Abstract: Processing video and sensor data associated with a vehicle Apparatus (5) is configured to: obtain first data corresponding to video data from a video camera(6) associated with a vehicle; obtain second data corresponding to sensor data from one or more sensors (8) associated with the vehicle;forma data structure including metadata and the first and second data, wherein first timing information for the first data is included in the metadata and second timing information for the second data is included in the second data, wherein the first and second timing information enable the first and second data to be temporally related.

WO 2015/082941 A3

**WO 2015/082941 A3** 

- (84) Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).
- Published:**
- *with international search report (Art. 21(3))*
  - *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*
- (88) Date of publication of the international search report:**  
30 July 2015

## TITLE

Processing video and sensor data associated with a vehicle

## FIELD

The present invention relates to processing video and sensor data associated with a vehicle.

## 5 BACKGROUND

Obtaining and analysing data from, for example, video cameras, positioning systems and certain other sensors associated with a vehicle is useful in assessing driver performance in the context of motorsport or everyday driving. Devices are known which can record video, and log global positioning system (GPS) and controller area network (CAN) bus data. Means for playing back such data are also known.

## SUMMARY

According to first and second aspects of the present invention, there is provided, respectively, a method as specified in claim 1 and apparatus as specified in claim 12.

Thus, the first and second aspects of the present invention can enable sensor data to be stored efficiently and/or with suitably precise timing information in the same data structure as video data which is stored in a form suitable for playback of the video. Moreover, the sensor data and the video data can still be temporally related, facilitating assessment of driver performance.

The one or more sensors associated with the vehicle include one or more sensors which are neither video nor audio sensors.

20 According to third and fourth aspects of the present invention, there is provided, respectively, a method as specified in claim 23 and apparatus as specified in claim 35.

Thus, the third and fourth aspects of the present invention can enable first data associated with a vehicle and second data associated with a vehicle to be played back in such a way as to facilitate comparisons between the first and second data.

25 Optional features of the present invention are specified in the dependent claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

Certain embodiments of the present invention will be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 illustrates a system in which are processed video, audio and sensor data associated with a vehicle;

Figure 2a illustrates a data structure formed by the system of Figure 1;

Figure 2b illustrates a part of the data structure of Figure 2a in more detail;

Figure 2c illustrates a part of the data structure of Figure 2b in more detail;

Figure 3 illustrates a box which is a constituent of the data structure of Figures 2a;

35 Figure 4 illustrates, in another way, the data structure of Figure 2a;

Figure 5 illustrates certain operations which may be performed by a data processor in the system of Figure 1;

Figure 6 illustrates apparatus for displaying data associated with a vehicle;

Figure 7 illustrates certain operations which may be performed by the apparatus of Figure 6;

Figure 8 illustrates equivalent positions of a vehicle or vehicles; and  
Figure 9 illustrates an example display provided by the apparatus of Figure 6.

#### DETAILED DESCRIPTION OF THE CERTAIN EMBODIMENTS

5 Referring to Figure 1, a system 1 according to a certain embodiment of the present invention will now be described. The system 1 can be included in a vehicle (not shown), for example a car. The system 1 includes a data processor 5, a video camera 6, a microphone 7, four sensors 8, a storage device 9 and a user-interface 10. The sensors 8 include a GPS sensor 11 and three other sensors 12, two of which are connected to a CAN bus 13. In certain other embodiments, the system 1 may  
10 include different numbers of certain elements, particularly those indicated by the reference numbers 6, 7, 8, 9, 10, 11, 12, 13, and/or need not include certain elements, particularly those indicated by the reference numbers 7, 10, 11, 12, 13.

The data processor 5 preferably corresponds to a microcontroller, a system on a chip or a single-board computer. The data processor 5 includes a processor 51, volatile memory 52, non-volatile  
15 memory 53, and an interface 54. In certain other embodiments, the data processor 5 may include a plurality of processors 51, volatile memories 52, non-volatile memories 53 and/or interfaces 54. The processor 51, volatile memory 52, non-volatile memory 53 and interface 54 communicate with one another via a bus or other form of interconnection 55. The processor 51 executes computer-readable instructions 56, e.g. one or more computer programs, for performing certain methods  
20 described herein. The computer-readable instructions 56 are stored in the non-volatile memory 53. The interface 54 is operatively connected to the video camera 6, the microphone 7, the sensors 8 (via the CAN bus 13 where appropriate), the storage device 9 and the user interface 10 to enable the data processor 5 to communicate therewith. The data processor 5 is provided with power from a power source (not shown), which may include a battery.

25 The video camera 6 is preferably arranged to provide a view similar to that of a driver in a normal driving position, and the microphone 7 is preferably arranged in the interior of the vehicle. However, the video camera 6 and/or microphone may be arranged differently. The microphone 7 may be integral with the video camera 6.

The GPS sensor 11 includes an antenna (not shown) and a GPS receiver (not shown). In certain other  
30 embodiments, the system 1 may include one or more other types of positioning system devices as an alternative to, or in addition to, the GPS sensor 11.

The other sensors 12 preferably include one or more of the following: an engine control unit (ECU), a transmission control unit (TCU), an anti-lock braking system (ABS), a body control module (BCM), a sensor configured to measure engine speed, a sensor configured to measure vehicle speed, an  
35 oxygen sensor, a brake position or pressure sensor, an accelerometer, a gyroscope, a pressure sensor and any other sensor associated with the vehicle. Each of these other sensors 12 may be connected to the interface 54 via the CAN bus 13 or not.

The storage device 9 preferably includes a removable storage device, preferably a solid-state storage device. In certain other embodiments, a communications interface for communicating with a  
40 remote device may be provided as an alternative to, or in addition to, the storage device 9.

The user interface 10 preferably includes a user input (not shown), a display (not shown) and/or a loudspeaker (not shown). In certain other embodiments, the user interface 10 may share common elements with an in-car entertainment system. The user interface 10 is configured to enable a user to control operations of the data processor 5, for example to set options, and start and stop the obtaining (i.e. recording) of data by the data processor 5. The user interface 10 is also preferably configured to enable a user to view the data obtained by the data processor 5, for example to view the video data and the sensor data in a suitable form.

As will be explained in more detail below, the data processor 5 is configured to obtain data from the video camera 6, microphone 7 and sensors 8, and to store corresponding data 22, 23, 24 (Figure 2a) in a data structure 20 (Figure 2a) in the storage device 9. The data 22, 23, 24 corresponding to the data obtained from the video camera 6, microphone 7 and sensors 8 is hereinafter referred to as "video data", "audio data" and "sensor data" respectively. The data 22, 23, 24 can then be analysed, for example using a computer running a suitable computer program (hereinafter referred to as a "data reader"), to assess driver performance.

Referring particularly to Figure 2a, the data structure 20 will now be described. The data structure 20 includes some of the same elements as an MPEG-4 Part 14 ("MP4") file, as described in International Standards ISO/IEC 14496-12:2008, "Information technology – Coding of audio-visual objects – Part 12: ISO base media file format" and ISO/IEC 14496-14:2003, "Information technology – Coding of audio-visual objects – Part 14: MP4 file format". The first of these documents is hereinafter referred to simply as "ISO/IEC 14496-12". The data structure 20 is preferably such that it can be processed by a data reader operating according to the MPEG-4 Part 14 standard.

The data structure 20 includes metadata 21 (denoted by the letter "M" in the figure), video data 22 ("V"), audio data 23 ("A") and sensor data 24 ("S"). In certain other embodiments, the data structure 20 does not include audio data 23. The metadata 21, video data 22, audio data 23 and sensor data 24 are contained in a plurality of objects called boxes 30, which will be described in more detail below. Certain metadata 21 is contained in a first box 30<sub>1</sub>, namely a File Type box. The video data 22, audio data 23 and sensor data 24 are contained in a second box 30<sub>2</sub>, namely a Media Data box 30<sub>2</sub>. The remaining metadata 21 is contained in a third box 30<sub>3</sub>, namely a Movie box. In certain other embodiments, at least some of the video data 22, audio data 23 and sensor data 24 may be included in a further Media data box and/or in a separate data structure. The data structure 20, and, in particular, the Media Data box 30<sub>2</sub>, contains a plurality of a discrete portions 25<sub>1</sub>...25<sub>11</sub>, each discrete portion consisting of either video data 22, audio data 23 or sensor data 24. Thus, the method for forming (and for reading) the data structure 20 can be more efficient (e.g. in terms of memory and/or processor usage). In the example illustrated in the figure, there are 11 discrete portions 25<sub>1</sub>...25<sub>11</sub> arranged in a certain order. However, in other examples, there may be any number of discrete portions 25 arranged in any order. There may be a multiplicity, e.g. hundreds, of discrete portions 25.

Referring particularly to Figure 2b, the video data 22, audio data 23 and sensor data 24 will now be described in more detail. The video data 22, audio data 23 and sensor data 24 can be collectively referred to as media data 27. In each discrete portion 25, the media data 27 is stored in a series of Chunks 60, and each Chunk 60 consists of one or more Samples 61. In this example, each Chunk 60

consists of only one Sample 61. However, this need not be the case. Each Chunk 60 begins at a certain absolute location in the data structure 20.

The video data 22 is preferably stored in the data structure 20 in H.264/MPEG-4 Part 10 or, in other words, Advanced Video Coding (AVC) format, and the audio data 23 is preferably stored in the data structure 20 in Advanced Audio Coding (AAC) format. However, the video data 22 and/or the audio data 23 may be stored in different formats.

Referring particularly to Figure 2c, the sensor data 24 will now be described in more detail. Each Sample 61 of the sensor data 24 includes one or more readings 63. In the Sample 61, illustrated in the figure, there are five readings 63. However, there may be any number of one or more readings 63 (each of which may be a full reading 63' or a compact reading 63''). Each reading 63 includes a channel number 64, an actual reading 65 and a timestamp 66. A reading 63 may correspond to a full reading 63', which has a length of 16 bytes, or a compact reading 63'', which has a length of 8 bytes. The first two bits of the reading 63 indicates whether the reading 63 is a full reading 63' or a compact reading 63''. The format of a full reading 63' is shown in Table 1, together with a description of the elements thereof.

Table 1. The full reading 63'.

Byte(s)	Bits	Field	Description
0	0, 1	Reading type	11 indicates that the reading is a full reading.
	2	Validity Flag	Reserved for future use.
	3-7	Channel Number	Identifies the channel to which the reading applies.
1-3	All		
4-7	All	Reading	The reading value.
8-15	All	Timestamp	The time at which the reading was recorded.

The format of a compact reading 63'' is shown in Table 2, together with a description of the elements thereof.

Table 2. The compact reading 63'.

Byte(s)	Bits	Field	Description
0	0, 1	Reading type	01 indicates that the reading is a compact reading.
	2-7	Channel Number Offset	Identifies the channel to which the reading applies. This value is relative to the channel number from the preceding reading.
1-3	All	Reading Offset	The reading value, relative to the value from the preceding reading for the same channel.
4-7	All	Timestamp Offset	The time at which the sample was recorded, relative to the timestamp of the preceding reading.

In normal circumstances, the majority of the readings 63 can be compact readings 63'', thereby minimising the amount of memory and storage space required for the sensor data 24.

As will be explained in more detail below, each channel number is associated with a particular sensor 8 being the origin of the actual reading 65 (or with a particular type of reading from a sensor 8). Each Sample 61 can contain readings 63 associated with any one or more channels numbers in any order. Thus, the method for forming the data structure 20 can be more efficient (e.g. in terms of memory and/or processor usage). By way of example, the Sample 61<sub>9</sub> illustrated in the figure contains a first, full reading 63<sub>1</sub>' associated with a first channel ("#1"), a second, compact reading 63<sub>2</sub>" associated with the first channel ("#1"), a third, full reading 63<sub>3</sub>' associated with a second channel ("#2"), a fourth, compact reading 63<sub>4</sub>" associated with a third channel ("#3") and fifth, compact reading 63<sub>5</sub>" associated with the second channel ("#2").

Referring particularly to Figure 3, the structure of a box 30 will now be described in more detail. A box 30 consists of, firstly, a header 31 and, secondly, data 32. The header 31 consists of a first, four-byte field 31a to indicate the size of the box 30 (including the header 31 and the data 32) and then a second, four-byte (four-character) field 31b to indicate the type of the box 30. In the example illustrated in the figure, the box has a size of 16 bytes and has a type "boxA". A box 30 may contain one or more other boxes 30, in which case the size indicated in the header 31a of the box 30 includes the size of the other one or more boxes 30.

Referring particularly to Figure 4, the metadata 21 will now be described in more detail. As explained above, certain metadata 21 is included in the File Type ("ftyp") box 30<sub>1</sub> and the remaining metadata 21 is included in the Movie ("moov") box 30<sub>3</sub>.

The File Type box 30<sub>1</sub> is preferably or necessarily the first box 30 in the data structure 20. The boxes 30 other than the File Type box 30<sub>1</sub> can generally be included in the data structure 20, or in the box 30 in which they are included, in any order. The File Type box 30<sub>1</sub> provides information which may be used by a data reader to determine how best to handle the data structure 20.

The Movie box 30<sub>3</sub> contains several boxes which are omitted from the figure for clarity. For example, the Movie box 30<sub>3</sub> contains a Movie Header ("mvhd") box (not shown), which indicates, amongst other things, the duration of the movie.

Reference is made to ISO/IEC 14496-12 for information about the boxes 30 and the content of boxes 30 not described in detail herein.

The Movie box 30<sub>3</sub> contains first, second and third Track ("trak") boxes 30<sub>4</sub>', 30<sub>4</sub>", 30<sub>4</sub>". The first Track box 30<sub>4</sub>' includes metadata 21 relating to the video data 22, the second Track box 30<sub>4</sub>" includes metadata 21 relating to the audio data 23, and the third Track box 30<sub>4</sub>" includes metadata 21 relating to the sensor data 24. Each Track box 30<sub>4</sub> contains, amongst other boxes (not shown), a Media ("mdia") box 30<sub>5</sub>. Each Media box 30<sub>5</sub> contains, amongst other boxes (not shown), a Handler Reference ("hdlr") box 30<sub>6</sub> and a Media Information ("minf") box 30<sub>7</sub>.

Each Handler Reference ("hdlr") box 30<sub>6</sub> indicates the nature of the data 22, 23, 24 to which the metadata 21 in the Track box 30<sub>4</sub> relates, and so how it should be handled. The Handler Reference boxes 30<sub>6</sub>', 30<sub>6</sub>", 30<sub>6</sub>" in the first, second and third Track ("trak") boxes 30<sub>4</sub>', 30<sub>4</sub>", 30<sub>4</sub>" includes the codes "vide", "soun" and "ctbx", respectively, indicative of video data 22, audio data 23 and sensor data 24, respectively. The first two of these codes are specified in ISO/IEC 14496-12.

Each Media Information (“minf”) box 30<sub>7</sub> contains, amongst other boxes (not shown), a Sample Table (“stbl”) box 30<sub>8</sub>. Each Sample Table (“stbl”) box 30<sub>8</sub> contains, amongst other boxes (not shown), a Sample Description (“stds”) box 30<sub>9</sub>, a Decoding Time to Sample (“stts”) box 30<sub>10</sub>, a Sample To Chunk (“stsc”) box 30<sub>11</sub>, a Sample Size (“stsz”) box 30<sub>12</sub> and a Chunk Offset (“stco”) box 30<sub>13</sub>.

In the first and second (video and audio data) Track boxes 30<sub>4</sub>’, 30<sub>4</sub>”, the Sample Description boxes 30<sub>9</sub>’, 30<sub>9</sub>” includes information about the coding type used for the video data 22 and audio data 23, respectively, and any initialization information needed for that coding. In the third (sensor data) Track box 30<sub>4</sub>”, the Sample Description box 30<sub>9</sub>” contains a Custom (“marl”) box 30<sub>14</sub>, which will be described in more detail below.

In brief, the remaining boxes 30<sub>10</sub>, 30<sub>11</sub>, 30<sub>12</sub> in the Sample Table box 30<sub>8</sub> provide a series of lookup tables to enable a data reader to determine the Sample 61 associated with a particular time point and the location of the Sample 61 within the data structure 20.

In more detail, the Decoding Time to Sample box 30<sub>10</sub> enables a data reader to determine the times at which Samples 61 must be decoded. In the case of the sensor data 24, the Decoding Time to Sample box 30<sub>10</sub> need not be used. The Sample to Chunk box 30<sub>11</sub> enables a data reader to determine which Chunk 60 contains each of the Samples 61. As explained above, in this example, each Chunk 60 contains one Sample 61. The Sample Size box 30<sub>12</sub> enables a data reader to determine the sizes of the Samples 61. The Chunk Offset box 30<sub>13</sub> enables a data reader to determine the absolute locations of the Chunks 60 in the data structure 20.

The Custom box 30<sub>14</sub> contains a Header (“mrlh”) box 30<sub>15</sub>, a Values (“mrlv”) box 30<sub>16</sub> and a Dictionary (“mrlD”) box 30<sub>17</sub>.

The Header box 30<sub>15</sub> is to enable a data reader to determine whether they are compatible with the sensor data 24 in the data structure 20. Implementations must not read data from a major version they do not understand. The format of the Header box 30<sub>15</sub> is shown in Table 3. In the tables, the offset is relative to the start of the data 32 in the box 30.

Table 3. The format of the Header box 30<sub>15</sub>.

Field	Offset (bytes)	Size (bytes)	Type
Major Version	0	2	UInt16
Minor Version	2	2	UInt16

The Values box 30<sub>16</sub> includes metadata 21 relating to the recording as whole, such as the time and date of the recording, and the language and measurements units selected. The Values box 30<sub>16</sub> has a variable size. The Values box consists of zero or one or more blocks, each of which includes a field for the name of the metadata 21, a field for a code (“type code”) indicating the type of the metadata 21, and a field for the value of the metadata 21. The format of the block is shown in Table 4.

Table 4. The constituent block of the Values box

Field	Size (bytes)	Type
Name	4	UInt32
Type Code	4	UInt32
Value	Variable	Variable

The size and data type of the value field depends upon the type of metadata 21 in the block, as shown in Table 5.

Table 5. Sizes and data types of the value field associated with different type codes

Type Code	Description	Size (bytes)	Data Type
'strs'	Short string	64	String
'lang'	Short string	64	String
'strl'	Long string	256	String
'time'	Time (ISO 86301)	32	String
'date'	Date (ISO 86301)	32	String
'tmzn'	Time zone (ISO 86301)	32	String
'tstm'	Number of 100 nanosecond periods since the UTC epoch (Midnight, January 1 <sup>st</sup> , 1970).	8	UInt64
'focc'	A FourCC (four character code)	4	FourCC
'kvp'	Key-value pair	320	Key-Value Pair

5

The format of a key-value pair is shown in Table 6.

Table 6. The format of a key-value pair.

Field	Size (bytes)	Type
Key	64	String
Value	256	String

10

The Dictionary box 30<sub>17</sub> contains metadata 21 relating to each of the channel numbers in use. As explained above, each channel number is associated with a particular sensor 8 (or a particular type of reading from a sensor 8). The format of the Dictionary box 30<sub>17</sub> shown in Table 7.

Table 7. The format of the Dictionary box 30<sub>17</sub>.

Field	Description	Offset (bytes)	Size (bytes)	Type
Channel number	A unique identifier for the channel	0	2	UInt32
Channel quantity	The type of measurement represented by this channel. Examples include length, temperature and voltage.	4	4	UInt32
Channel units	The default measurement units to be used	8	4	UInt32
Units string	A string representation of the default units	12	64	String
Flags	Binary values to determine how to convert and display the data (see below).	76	4	UInt32
Interval	Approximate time between readings, based on the frequency of the CAN packet that carries this channel.	80	8	Timestamp
Minimum reading	The lowest possible reading, in raw values, as specified by the vehicle manufacturer.	88	4	Int32
Maximum reading	The highest possible reading, in raw values, as specified by the vehicle manufacturer.	92	4	Int32
Display minimum	The lowest possible reading, in display units.	96	8	Float64
Display maximum	The highest possible reading, in display units.	104	8	Float64
Multiplier	A multiplier for converting from raw to display values.	112	8	Float64
Offset	An offset for converting from raw to display values.	120	8	Float64
Channel name	A textual identifier for the channel	128	64	String
Channel description	A user-friendly description of the channel	192	256	String

The meaning of certain bits in the Flags field is explained in Table 8.

Table 8. The Flags field.

Bit	Meaning when set
0	Visible by default.
1	Linear conversion to measurement units is possible.
2	Interpolation permitted.

When bit 1 is set, the raw channel values can be converted to the corresponding measurement unit by applying the formula:  $\text{Converted value} = \text{Multiplier} \times \text{Raw value} + \text{Offset}$ . Otherwise, a unity conversion is assumed. When bit 2 is set, it is valid to interpolate between sample values. Otherwise, no interpolation should occur.

- 5 Referring particularly to Figure 5, certain operations which can be performed by the data processor 5 will now be described in more detail.

At step S80, the data processor 5 initialises. This step may be performed in response to a user input via the user interface 10. The initialisation may involve initiating several data structures, including the data structure 20, storing certain metadata 21, communicating with one or more of the sensors 8 and/or communicating with a user via the user interface 10.

At step S81, data is received from one (or more) of the sensors 8 via the interface 54.

At step S82, the type of data received is determined. If the data corresponds to video data 22, then the method proceeds to step S83a. If the data corresponds to audio data 23, then the method proceeds to step S83b. If the data corresponds to sensor data 24, then the method proceeds to step S83c.

At step S83a, the data corresponding to video data 23 is processed. For example, the data may be encoded or re-encoded into a suitable format, e.g. AVC format. In certain embodiments, the processing of the data may alternatively or additionally be carried out at step S86a.

At step S84a, the video data 22 and associated metadata 21, including e.g. timing information, is temporarily stored, for example in the volatile memory 52. The method then proceeds to step S85.

At step S83b, the data corresponding to the audio data 23 is processed. For example, the data may be encoded or re-encoded into a suitable format, e.g. AAC format. In certain embodiments, the processing of the data may alternatively or additionally be carried out at step S86b.

At step S84b, the audio data 23 and associated metadata 21, including e.g. timing information, is temporarily stored, for example in the volatile memory 52. The method then proceeds to step S85.

At step S83c, the data corresponding to the sensor data 24 is processed. For example, the data may be used to form a reading 63 (see Figure 2c). This may involve assigning a channel number based, for example, upon the sensor 8 from which the data was received. Forming a reading 63 may also involve generating timing information in the form of a timestamp. The same clock and/or timing reference is preferably used to generate the timing information for the sensor data 24 as that used for the video data 22 and audio data 24. Forming a reading 63 may also involve processing and re-formatting the data received from the sensor 8. In certain embodiments, the processing of the data may alternatively or additionally be carried out at step S86c. There is no need to separate readings 63 associated with different channels numbers.

At step S84c, the sensor data 24 and associated metadata 21 is temporarily stored, for example in the volatile memory 52. The method then proceeds to step S85.

At step S85, it is determined whether video data 22, audio data 23 or sensor data 24 is to be stored in the data structure 20 or no data is to be stored. This can be based on timing information or upon

the amount of data temporarily stored. If video data 22 is to be stored in the data structure 20, then the method proceeds to step S86a. If audio data 23 is to be stored in the data structure 20, then the method proceeds to step S86b. If sensor data 24 is to be stored in the data structure 20, then the method proceeds to step S86c. If no data is to be stored, then the method returns to step S81.

5 At step S86a, 86b or 86c, any further processing of the video data 22, audio data 23 or sensor data 24 is performed.

At step S87a, 87b or 87c, a discrete portion 25 of the video data 22, audio data 23 or sensor data is stored in the data structure 20.

At step S88a, 88b or 88c, associated metadata 21 is stored in the data structure 20.

10 At step S89, it is determined whether the data structure 20 is to be finalised. If so, then the method proceeds to step S90. If not, then the method returns to step S81.

At step S90, the data structure 20 is finalised, for example by storing (or moving) the metadata 21 in the Movie box 30<sub>3</sub> in the data structure 20.

15 Referring particularly to Figure 6, apparatus 100 according to a certain embodiment of the present invention will now be described. The apparatus 100 may correspond to a computer. The apparatus 100 includes one or more processors 101, memory 102, storage 103, and a user interface 104. The memory 102 includes volatile and/or non-volatile memory. The storage 103 includes, for example, a hard disk drive and/or a flash memory storage device reader. The user interface 104 preferably includes one or more user inputs, e.g. a keyboard, a mouse and/or a touch-sensitive screen, and one  
20 or more user outputs, including a display. The one or more processors 101, memory 102, storage 103 and user interface 104 communicate with one another via a bus or other form of interconnection 105. The one or more processors 101 execute computer-readable instructions 106, e.g. one or more computer programs, for performing certain methods described herein. The computer-readable instructions 106 may be stored in the storage 103.

25 As will be explained in more detail below, the apparatus 100 is configured to display data from first and second sets of data associated with a vehicle. The first and second sets of data are each preferably obtained and structured as described above with reference to Figures 1 to 5. The first and second sets of data each include video data and GPS (or other positioning) data, and preferably each include audio data and other sensor data. Display of the data preferably includes playback of  
30 video data and a corresponding time-varying display of sensor data or related data, e.g. timing information. Display of the data is hereinafter referred to as “playback” of the data.

The apparatus 100 is configured to control playback of the data from the first or second set of data in dependence upon the positioning data in the first and second sets of data. This is done such that the data from the first and second sets of data which is displayed at a particular time relates to  
35 equivalent positions of the vehicle or vehicles with which the first and second data are associated. For example, the effective playback rate of the data from the first or second set of data is increased or decreased relative to the other to compensate for the vehicle or vehicles taking different lengths of time to move between equivalent positions. Controlling the playback of the data in this way is hereinafter referred to as “playback alignment”. The vehicle with which the first set of data is  
40 associated is hereinafter referred to as the “first vehicle” and the vehicle with which the second set

of data is associated is hereinafter referred to as the “second vehicle”, although, as will be appreciated, the first and second vehicles may be the same vehicle.

Referring particularly to Figure 7, certain operations which can be performed by the apparatus 100 will now be described.

- 5 At steps S101 and S102 respectively, the first and second sets of data are obtained. This may involve transferring the sets of data from the storage 103 into the memory 102. Preferably, a user can select the sets of data to be obtained via the user interface 104. The sets of data may be re-structured as appropriate, e.g. to facilitate access to the data.

10 The second set of data may correspond to part of a larger set of data. In particular, the second set of data may correspond to a particular lap of a number of laps around a circuit. In this case, when a set of data including a number of laps is selected by a user, the first lap of the selected set of data is preferably used as the second set of data. Preferably, a user can change the lap to be used as the second set of data via the user interface 104.

15 At step S103, data for facilitating the playback alignment (hereinafter referred to as “alignment data”) is determined. This step is preferably carried out whenever a second set of data is obtained or a first or second set of data is changed. The step may involve checking that the first and second sets of data are comparable, e.g. relate to the same circuit.

20 In this example, the alignment data takes the form of an array of map distances and respective timing information, i.e. respective timestamps. The alignment data is preferably formatted in the same way as the abovedescribed channels, except that the alignment data need not include channel numbers. The timestamps in the alignment data correspond to, e.g. use the same time reference as, the timing information for the data, e.g. video and GPS data, included in the first and second sets of data. The alignment data is preferably stored in the memory 102

25 At step S103a, the alignment data for the second set of data (hereinafter referred to as “second alignment data”) is determined. The map distances for the second alignment data (hereinafter referred to as “second map distances”) correspond to the distance travelled by the second vehicle from a defined start point, e.g. the start of the lap. The second map distances are preferably determined from the GPS data included in the second set of data. The GPS data, e.g. latitude and longitude readings, may be converted to local X, Y coordinates to facilitate this. The positions  
30 determined from the GPS data are hereinafter referred to as “recorded positions”. The second map distances are preferably determined for each recorded position of the second vehicle, i.e. at the same timestamps as the GPS readings. Each second map distance (other than the first, which is zero) is preferably determined from the previous second map distance by adding the straight-line distance between the current and previous recorded positions of the second vehicle.

35 At step S103b, the alignment data for the first set of data (hereinafter referred to as “first alignment data”) is determined. The map distances for the first alignment data (hereinafter referred to as “first map distances”) are determined such that when the first and second vehicles are at equivalent positions (which is not generally at the same time), the first and second map distances are the same.

40 Referring also to Figure 8, the equivalent positions will now be described in more detail. The figure illustrates a section of track 110 and paths 111, 112 taken by the first and second vehicles around

the section of track 110. The first and second vehicles are considered to be at equivalent positions 113, 114 when the position 113 of the first vehicle is substantially on the same line 115 (in the X-Y plane) as the position 114 of the second vehicle, wherein the line 115 is perpendicular to the direction of movement (e.g. the heading) of the second vehicle at the position 114.

5 Preferably, for each recorded position of the second vehicle and corresponding second map distance, an equivalent position of the first vehicle is determined. The equivalent position may be determined to be the recorded position of the first vehicle which is closest to the line 115. However the equivalent position is preferably obtained by extrapolation or interpolation based upon the one or two recorded positions of the first vehicle which is or are closest to the line 115. The recorded  
10 positions of the first and second vehicles are illustrated by the dots in the dash-dot lines 111, 112 in the figure. The second map distance is then stored in the first alignment data with a timestamp that corresponds to the timestamp associated with the closest recorded position of the first vehicle or, as the case may be, a timestamp obtained by extrapolation or interpolation.

15 When determining which recorded position(s) of the first vehicle should be used as, or to determine, the equivalent position, information about the distances travelled by the first and second vehicles since the last known equivalent positions may be used. For example, this information may be used to determine a weighting to distinguish between recorded positions of the first vehicle which are similarly close to the line 115, but which relate to different points on the path 111 taken by the first vehicle, e.g. at the start or end of a lap or the entry or exit to or from a hairpin corner.

20 In other examples, the alignment data may be determined differently. For example, the alignment data for the first set of data may be determined according to the abovedescribed principle for determining equivalent positions but using a different algorithm. The principle for determining equivalent positions may be different, e.g. it may involve using information about the track. The alignment data may be different.

25 At step S104, playback of the data is started. This may be in response to a user input via the user interface 104. Preferably, the user is able to select which of the first and second sets of data is played back at a constant rate, e.g. in real-time, and which is played back at a variable rate. The following description is provided for the case where the second set of data is played back at a constant rate and the first set of data is played back at a variable rate.

30 At step S105, data from the first and second sets of data is played back. The effective playback rate of data from the second set of data is preferably controlled using a clock. The effective playback rate of data from the first set of data is varied using the alignment data. In particular, as data from the second set of data is played back, map distances are obtained from the second alignment data, equivalent map distances are found in the first alignment data, and the timestamps associated  
35 therewith are used to determine which data from the first set of data are to be displayed. Accordingly, for example, the frame rate of the video data from the first set of data may be increased or decreased and/or frames of the video data from the first set of data may be repeated or omitted as appropriate.

40 Referring also to Figure 9, an example display 120 provided by the user interface 104 will now be described. The display 120 includes first and second display regions 121, 122 for displaying data from the first and second sets of data, respectively. As can be seen e.g. from the video images 123,

124, the first and second vehicles are at equivalent positions, whereas the times 125, 126 since e.g. the beginning of the lap are different from each other, as are the distances travelled by the first and second vehicles. Thus, data associated with the first and second vehicles is displayed at equivalent positions of the first and second vehicles, thereby facilitating comparisons therebetween.

- 5 At step S106, playback of the data is stopped. This may be in response to a user input via the user interface 104.

Various further operations (not shown in the figure) may be performed in response to various user inputs via the user interface 104.

- 10 For example, playback of data from the second set of data may be “scrubbed”, that is to say caused to play back more quickly or more slowly than real-time, or stepped forwards or backwards in time. In such cases, playback of data from the first set of data is controlled appropriately to maintain the playback alignment as described above.

Playback of the data may be re-started, in which case the process returns to step S104. The same or the other one of the first and second sets of data may be played back at a constant rate.

- 15 A different second set of data may be obtained, in which case the process returns to step S102. A different first set of data may be obtained, in which case the process returns to step S101 and, after this step, proceeds to step S103.

It will be appreciated that many other modifications may be made to the embodiments hereinbefore described.

- 20 For example, one or more parts of the system 1 may be remote from the vehicle.

## CLAIMS

1. A method comprising:
  - obtaining first data associated with a first vehicle, the first data comprising first positioning data indicative of positioning of the first vehicle and first video data from a first camera associated with the first vehicle and indicative of a first point of view from the first vehicle;
  - obtaining second data associated with the first vehicle or a second vehicle, the second data comprising second positioning data indicative of positioning of the first vehicle or positioning of the second vehicle and second video data from the first camera associated with the first vehicle indicative of the first point of view from the first vehicle or from a second camera associated with the second vehicle indicative of a second point of view from the second vehicle;
  - determining first alignment data for the second data, the first alignment data comprising an array of map distances and respective timing information, the map distances corresponding to a distance travelled from a defined start point;
  - determining second alignment data for the first set of data such that when the first vehicle and the second vehicle are at equivalent positions, the map distances for the first vehicle and the second vehicle are the same; and
  - causing at least some of the first video data comprised in the first data and at least some of the second video data comprised in the second data to be displayed, a first effective playback data rate from the second data being controlled using a clock and a second effective playback data rate from the first data is varied using the first and second alignment data such that the first and second video data from the first and second data which is displayed at a particular time relates to equivalent positions of the first vehicle and first or second vehicle with which the first and second data are associated.
  
2. A method according to claim 1, wherein the first vehicle and the first or second vehicle are at equivalent positions when positioned on substantially a same line, wherein the line is substantially perpendicular to a direction of movement of the first or second vehicle with which the second data are associated.
  
3. A method according to claim 1 or 2, wherein determining the equivalent positions comprises extrapolating or interpolating based on one or more recorded positions of the first vehicle with which the first data are associated.
  
4. A method according to any one of claims 1 to 3 wherein determining the equivalent positions comprises using information about the distances travelled by the first vehicle and the first or second vehicles since previous equivalent positions.
  
5. A method according to any one of claims 1 to 4, comprising:
  - parameterising a path taken by the first or second vehicle with which the second data are

associated; and

parameterising the path taken by the first vehicle with which the first data are associated such that, when the first vehicle and first or second vehicle are at equivalent positions, the parameters used to parameterise the paths taken by the first vehicle and the first or second vehicle are substantially equal.

6. A method according to claim 5, wherein parameterising the path taken by the first or second vehicle with which the second data are associated comprises determining the distance travelled by the first or second vehicle with which the second data are associated as a function of time.

7. A method according to claim 6, wherein parameterising the path taken by the first vehicle with which the first data are associated comprises, for each of a set of distances travelled by the first or second vehicle with which the second data are associated:

determining the time at which the first vehicle with which the first data are associated is at an equivalent position to the first or second vehicle with which the second data are associated; and associating the distance travelled by the first or second vehicle with which the second data are associated with the determined time.

8. A method according to any one of claims 5 to 7, wherein controlling display of the first data comprises:

determining the parameter of the path taken by the first or second vehicle associated with the second data at the particular time;

determining the time at which the parameter of the path taken by the first vehicle associated with the first data is substantially equal to the determined parameter; and

displaying the first data corresponding to the determined time.

9. A method according to any one of claims 5 to 8, wherein controlling display of the second data comprises:

determining the parameter of the path taken by the first vehicle associated with the first data at the particular time;

determining the time at which the parameter of the path taken by the first or second vehicle associated with the second data is substantially equal to the determined parameter; and displaying the second data corresponding to the determined time.

10. A method according to any one of claims 1 to 9, wherein display of the first or second data is controlled in dependence upon a user input selecting the first or second data.

11. A non-transient computer-readable storage medium storing a computer program for performing a method comprising:
- obtaining first data associated with a first vehicle, the first data comprising first positioning data indicative of positioning of the first vehicle and first video data from a first camera associated with the first vehicle and indicative of a first point of view from the first vehicle;
  - obtaining second data associated with the first vehicle or a second vehicle, the second data comprising second positioning data indicative of the positioning of the first vehicle or positioning of the first or second vehicle and second video data from the first camera associated with the first vehicle indicative of the first point of view from the first vehicle or from a second camera associated with the second vehicle indicative of a second point of view from the second vehicle; and
  - determining first alignment data for the second data, the first alignment data comprising an array of map distances and respective timing information, the map distances corresponding to a distance travelled from a defined start point;
  - determining second alignment data for the first set of data such that when the first and second vehicles are at equivalent positions the map distances for the first and second vehicles are the same; and
  - causing at least some of the first video data comprised in the first data and at least some of the second video data comprised in the second data to be displayed, a first effective playback data rate from the second data being controlled using a clock and a second effective playback data rate from the first data is varied using the first and second alignment data such that the first and second data which is displayed at a particular time relates to equivalent positions of the first vehicle and the first or second vehicle with which the first and second data are associated.
12. An apparatus configured to:
- obtain first data associated with a first vehicle, the first data comprising first positioning data indicative of positioning the first vehicle and first video data from a first camera associated with the first vehicle and indicative of a first point of view from the first vehicle;
  - obtain second data associated with the first vehicle or a second vehicle, the second data comprising second positioning data indicative of positioning of the first vehicle or positioning of the second vehicle and second video data from the first camera associated with the first vehicle indicative of the first point of view from the first vehicle or from a second camera associated with the second vehicle indicative of a second point of view from the second vehicle;
  - determining first alignment data for the second data, the first alignment data comprising an array of map distances and respective timing information, the map distances corresponding to a distance travelled from a defined start point;
  - determining second alignment data for the first set of data such that when the first and second vehicles are at equivalent positions the map distances for the first and second vehicles are the same; and
  - cause at least some of the first video data comprised in the first data and at least some of the second video data comprised in the second data to be displayed, a first effective playback data rate from the second data being controlled using a clock and a second effective playback data rate from the first data is varied using the first and second alignment data such that the first and second data which is displayed at a particular time relates to equivalent positions of the first vehicle and the first or second vehicle with which the first and second data are associated.

13. The apparatus according to claim 12, wherein the first vehicle and the first or second vehicle are at equivalent positions when positioned on substantially a same line, wherein the line is substantially perpendicular to a direction of movement of the first or second vehicle with which the second data are associated.
14. The apparatus according to claim 12 or 13, configured to determine the equivalent positions by extrapolating or interpolating based on one or more recorded positions of the first vehicle with which the first data are associated.
15. The apparatus according to any one of claims 12 to 14, configured to determine the equivalent positions by using information about the distances travelled by the first vehicle and the first or second vehicle since previous equivalent positions.
16. The apparatus according to any one of claims 12 to 15, configured to:  
parameterise a path taken by the first or second vehicle with which the second data are associated; and  
parameterise the path taken by the first vehicle with which the first data are associated such that, when the first vehicle and the first or second vehicle are at equivalent positions, the parameters used to parameterise the paths taken by the first vehicle and the first or second vehicle are substantially equal.
17. The apparatus according to claim 16, configured to parameterise the path taken by the first or second vehicle with which the second data are associated by determining a distance travelled by the first or second vehicle with which the second data are associated as a function of time.
18. The apparatus according to claim 17, configured to parameterise the path taken by the first vehicle with which the first data are associated by, for each of a set of distances travelled by the first or second vehicle with which the second data are associated:  
determining the time at which the first vehicle with which the first data are associated is at an equivalent position to the first or second vehicle with which the second data are associated; and  
associating the distance travelled by the first or second vehicle with which the second data are associated with the determined time.
19. The apparatus according to any one of claims 16 to 18, configured to control display of the first data by:

determining the parameter of the path taken by the first or second vehicle associated with the second data at a particular time;

determining the time at which the parameter of the path taken by the first vehicle associated with the first data is substantially equal to the determined parameter; and

5 displaying first data corresponding to the determined time.

20. The apparatus according to any one of claims 16 to 18, configured to control display of the second data by:

10 determining the parameter of the path taken by the first vehicle associated with the first data at a particular time;

determining the time at which the parameter of the path taken by the first or second vehicle associated with the second data is substantially equal to the determined parameter; and

displaying second data corresponding to the determined time.

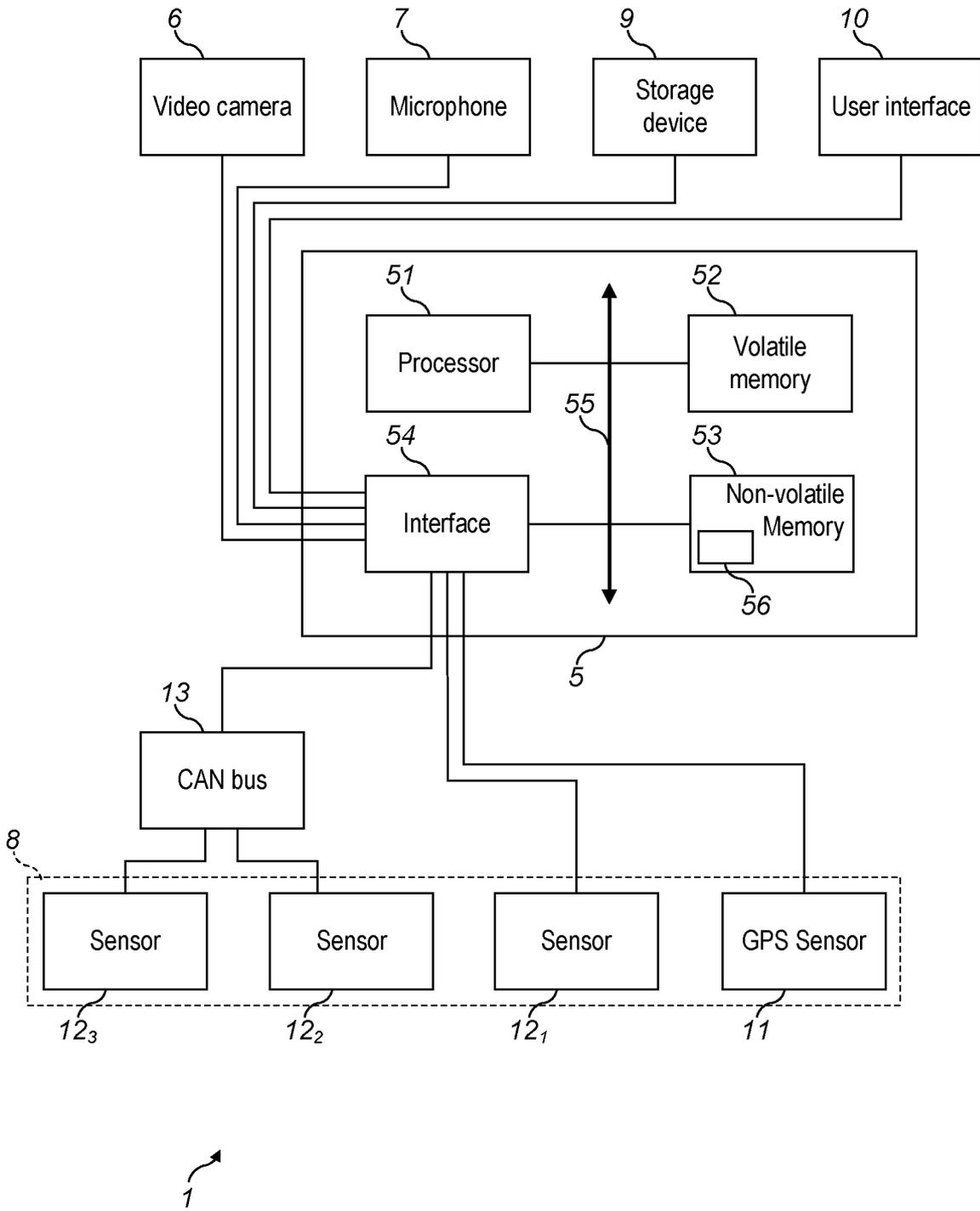


FIG. 1

2 / 8

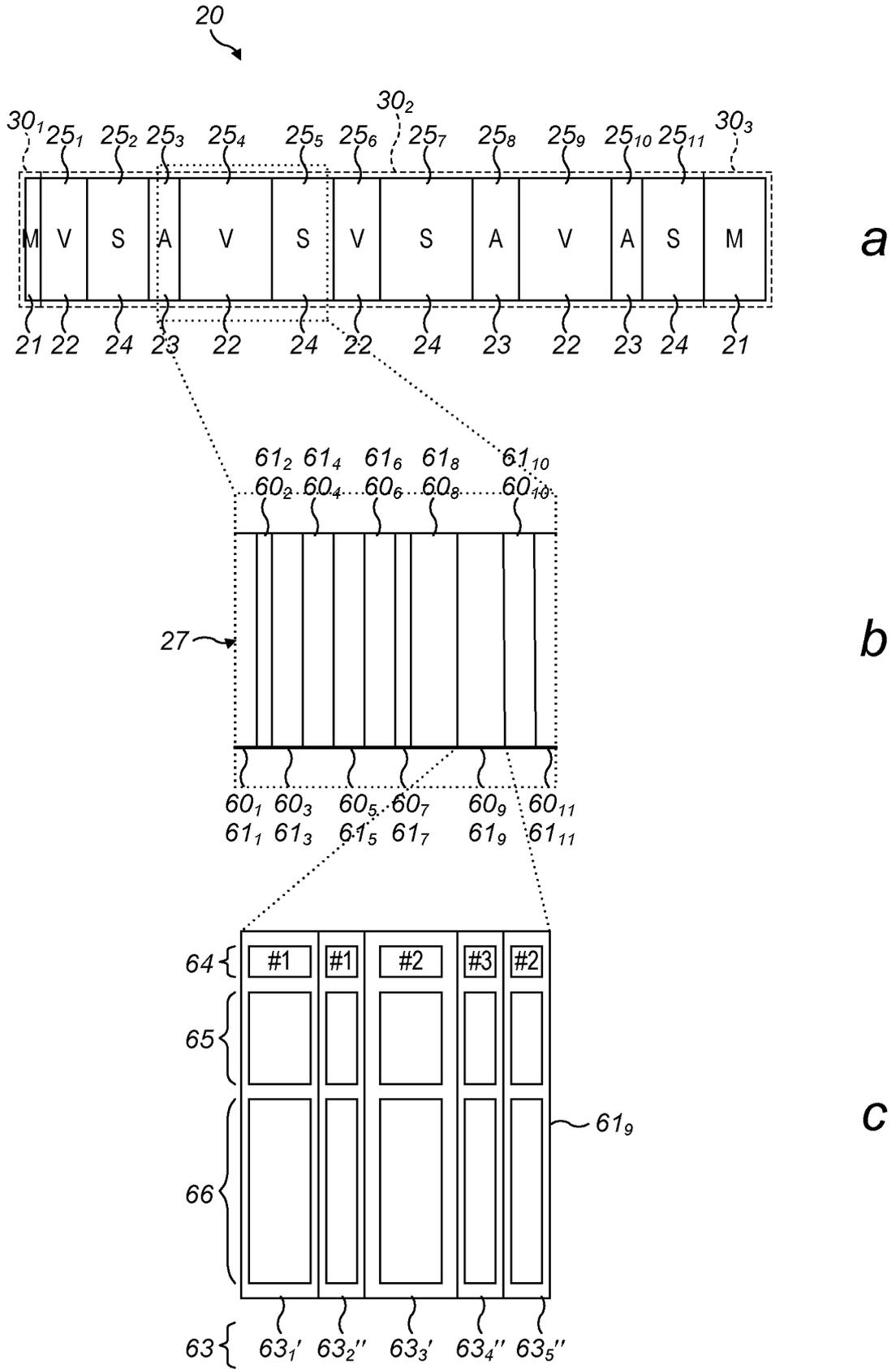


FIG. 2

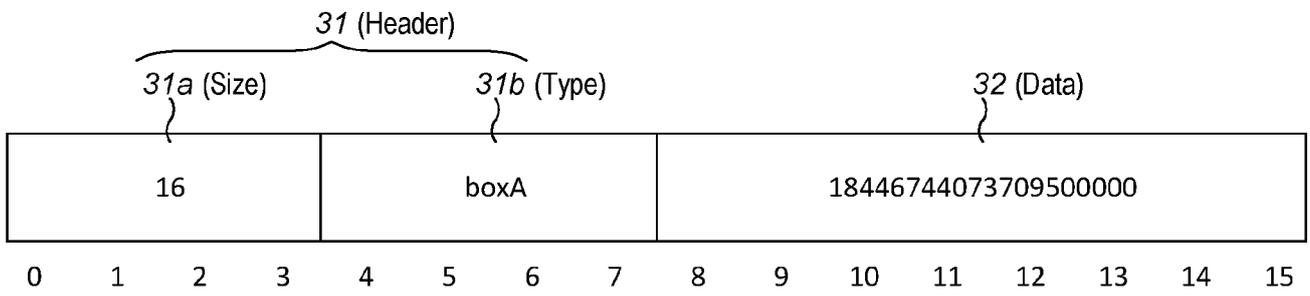


FIG. 3

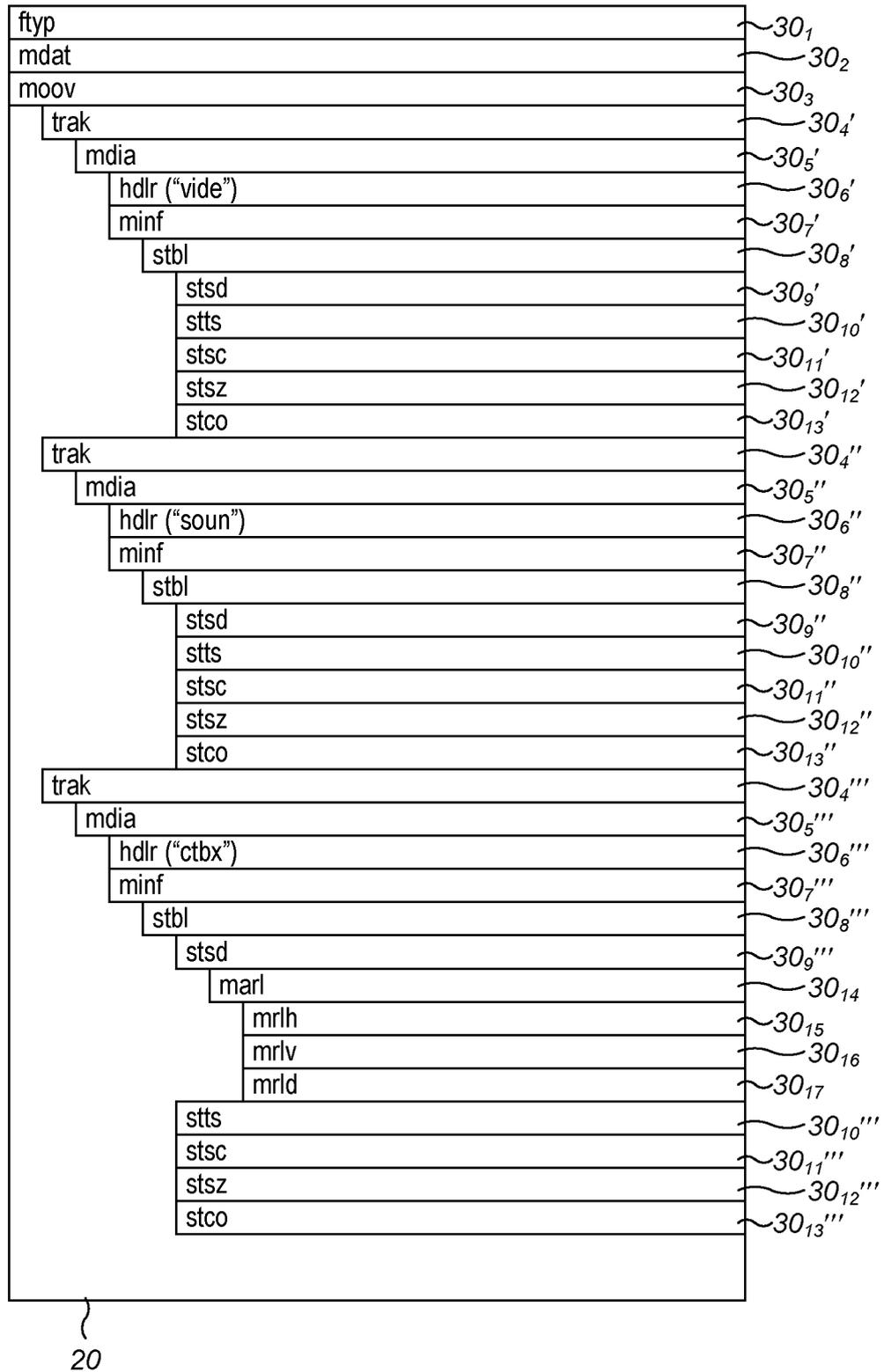


FIG. 4

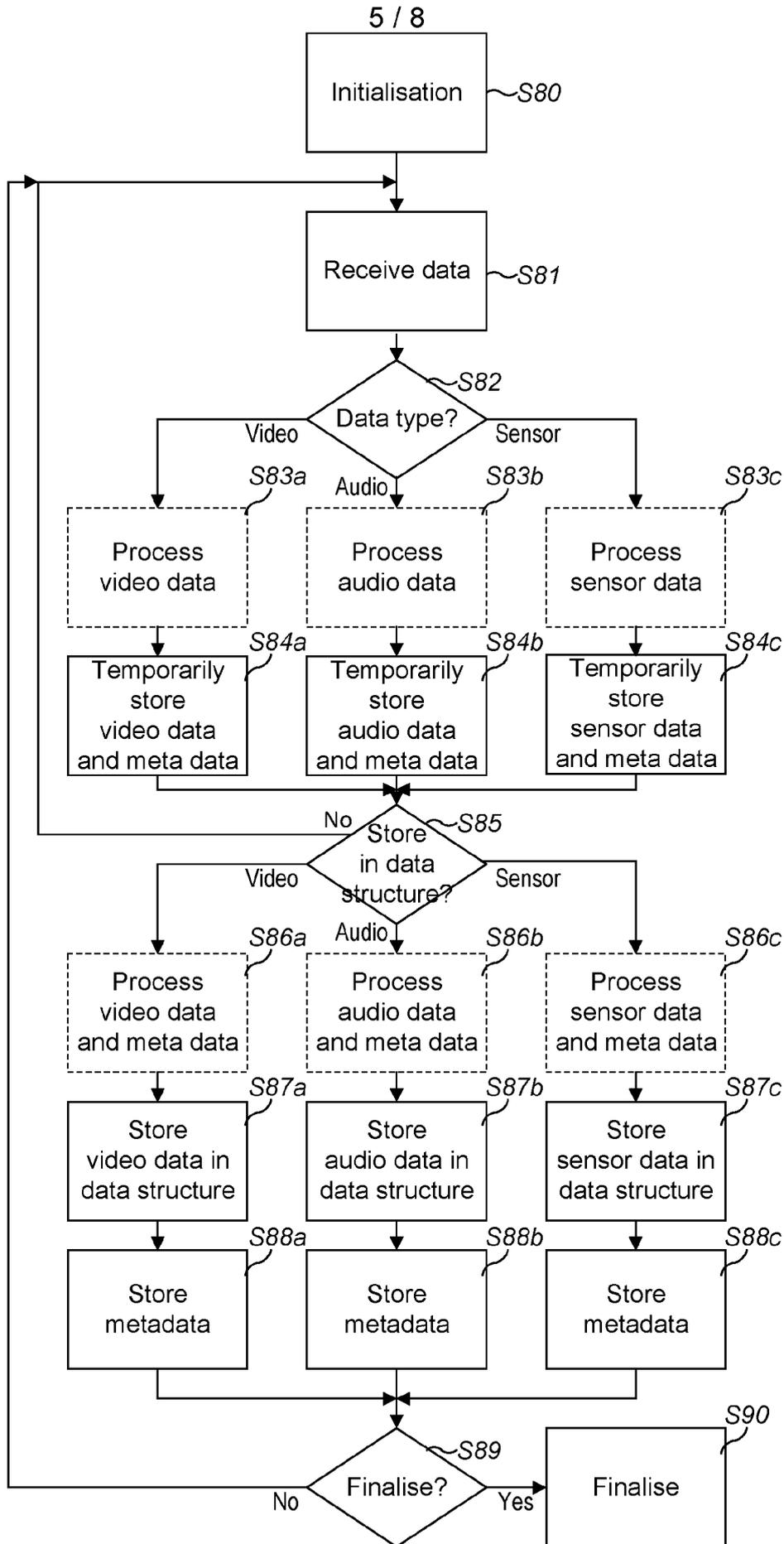


FIG. 5

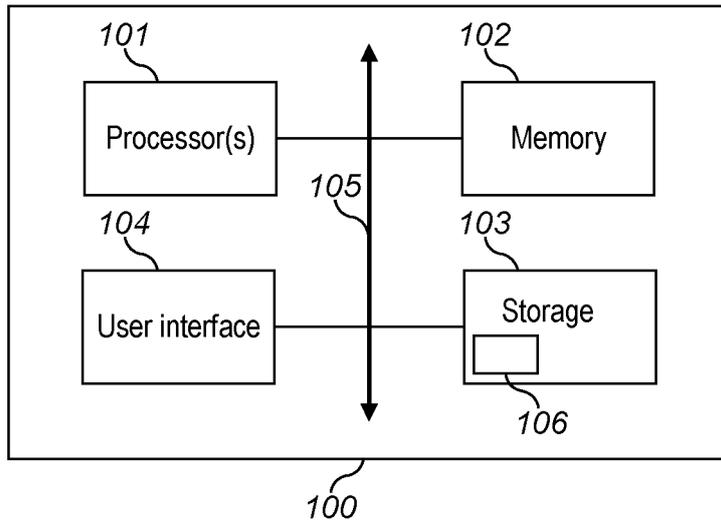


FIG. 6

7 / 8

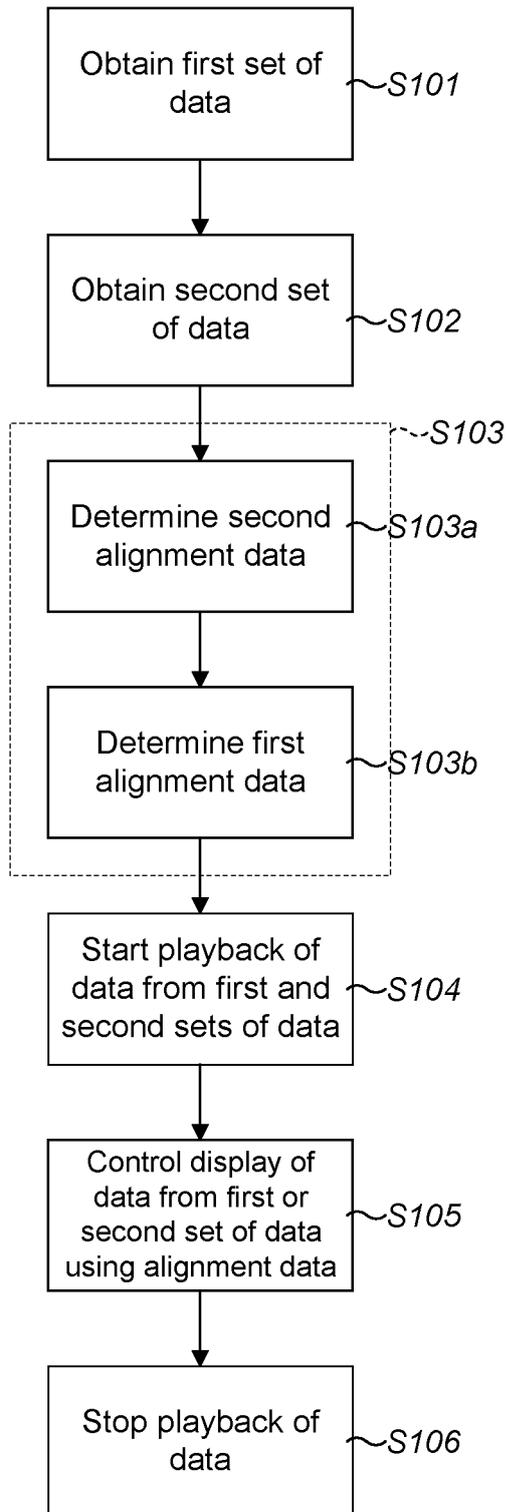


FIG. 7

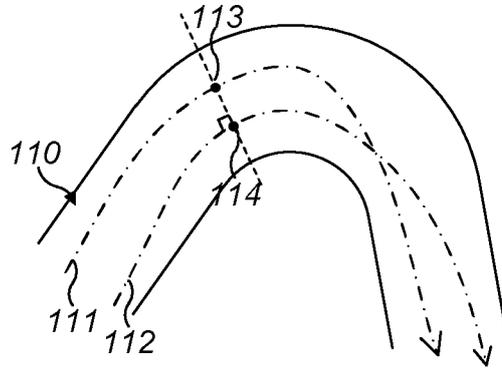


FIG. 8

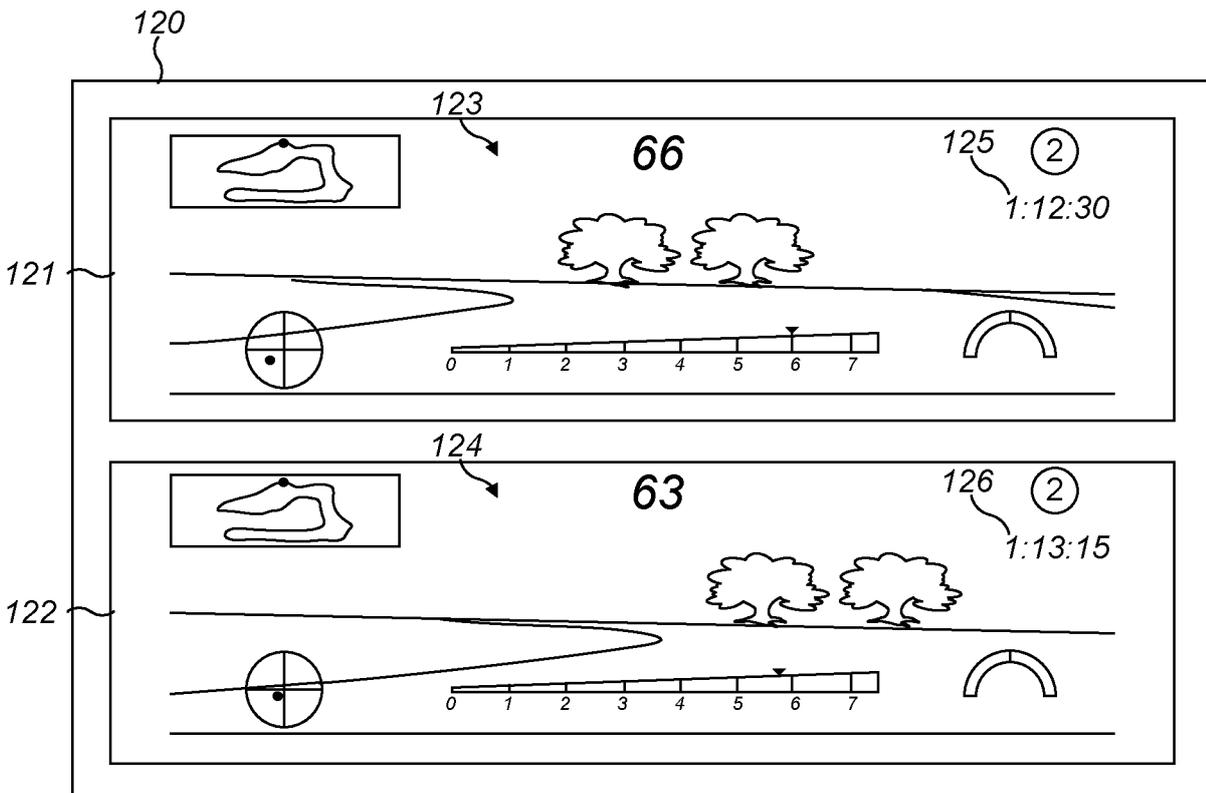
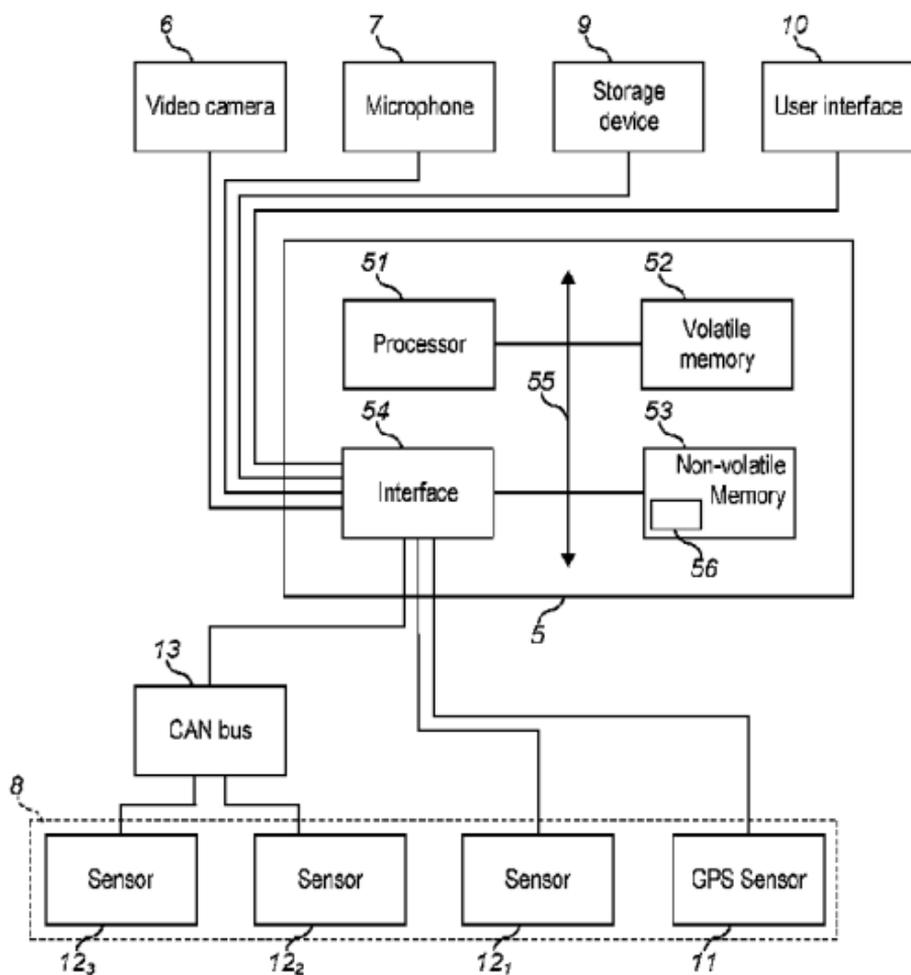


FIG. 9



f