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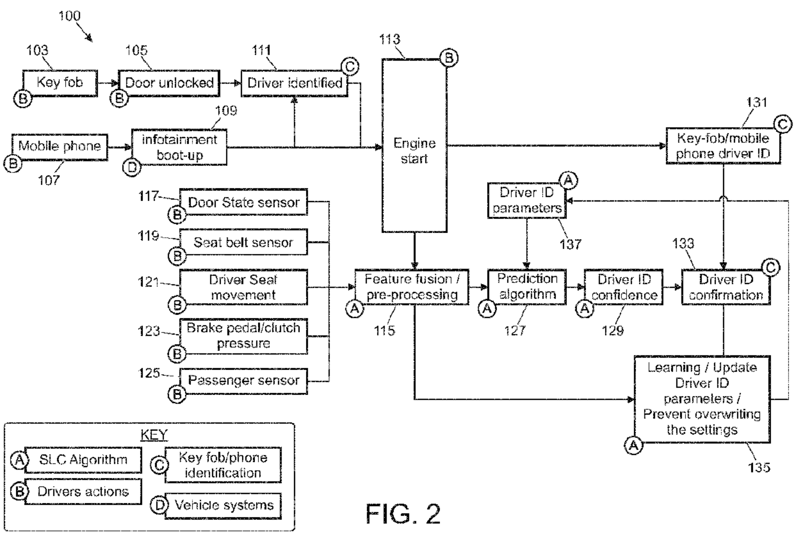

FIG. 2

(57) Abstract: The present application discloses a method of identifying a vehicle user associated with one of a plurality of stored user profiles. At least first and second parameters are acquired. The first parameter is acquired from a first node at a first time and the second parameter is acquired from a second node at a second later time. The first parameter is analysed to identify the vehicle user, before the second time. The second parameter is analysed to identify the vehicle user. The application also discloses a computer program, a vehicle (V) and a vehicle control apparatus (1) for identifying a user.

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IDENTIFICATION METHOD AND APPARATUS

TECHNICAL FIELD

The present disclosure relates to a method of identifying a vehicle user; a computer program; an apparatus for identifying a vehicle user; and to a vehicle.

BACKGROUND

It is desirable to identify a vehicle user, for example to enable vehicle settings to be set to match the particular preferences of a user. Currently there is no unobtrusive and accurate way for identifying the vehicle user. One approach is to request that the vehicle user confirm their identity, for example by manually selecting a user profile from a menu. However, this requires input from the user each time they enter the vehicle.

The use of biometric sensors is becoming increasingly common in many fields. However, these may not always provide an accurate finding. There remain certain limitations with these systems which cannot readily be overcome. The system has to rely on one identification sensor which may not be accurate or could fail in some circumstances. For example, a fingerprint sensor would not operate if the vehicle user was wearing gloves.

It is against this backdrop that the present invention has been conceived. At least in certain embodiments the present invention sets out to overcome or ameliorate at least some of the shortcomings associated with prior art systems.

SUMMARY OF THE INVENTION

Aspects of the present application relate to a method of identifying a vehicle user; a computer program; an apparatus for identifying a vehicle user; and to a vehicle.

According to a further aspect of the present invention there is provided a method of identifying a vehicle user associated with one of a plurality of stored user profiles, the method comprising:

acquiring at least first and second parameters, the first parameter being acquired from a first node at a first time, and the second parameter being acquired from a second node at a second later time;

performing first analysis of at least said first parameter, before the second time, to identify the vehicle user; and

performing second analysis of at least said second parameter to identify the vehicle user. An advantage of this recursive method is identifying a vehicle user as early as possible, by performing first analysis to identify the vehicle user before the second parameter is available.

The first analysis can comprise determining a first probability of the vehicle user being associated with one of said stored user profiles. The method can comprise updating the first probability with a result of the second analysis to determine a second probability of the vehicle user being associated with one of said stored user profiles.

Updating the first probability with the result of the second analysis can be in dependence on a conflict condition associated with the second parameter. The first probability may not be updated if the first analysis and the second analysis identify different vehicle users. Conveniently, parameters from unreliable nodes may be discarded.

The second probability may be compared to a predetermined belief threshold, the vehicle user being identified if the determined probability exceeds said predetermined belief threshold.

Subsequent to performing said second analysis, the method can be repeated after a delay or if a condition associated with a change of vehicle user is satisfied.

The method can comprise acquiring more than two parameters. Each parameter can be acquired from a corresponding independent node. At least said first and second parameters form a collective identifier which is unique to each user, thereby allowing the vehicle user to be identified. In the context of implementing the method described herein, the nodes function as identification nodes.

The method can be used to identify the user from a plurality of candidate users. A self-learning algorithm can be implemented to establish a link or association between at least said first and second parameter and each user having a stored user profile. The link can be updated dynamically, for example in dependence on data generated during a learning phase or subsequently from on-going implementation of the method. The method can provide improved system belief about the identity of a vehicle user based on the new evidence that is acquired.

The method can identify the user based on a combination of physiological biometrics and/or behavioural biometrics and/or usage analytics. The physiological biometrics can include one or more of the following: face, fingerprint, voice and cardiac rhythm. The behavioural biometrics and/or usage analytics can include one or more of the following: steering wheel holding pattern; brake pedal pressure values; clutch pedal pressure values; driver door to engine start time; height; and weight (a soft biometric - as changes and requires learning). The behavioural biometrics include one or more of the following: vehicle usage based on day and time; phone (or any wireless Personal device which could be coupled to the vehicle); key fob usage; memory switch usage; a seat position; seat movement; seatbelt length; and location (GPS data) based usage.

A first and second belief of identity (BOI) value can be determined in dependence on said first and second nodes respectively. The first and second belief of identity values can be in the form of probability information. The analysis of the first and second parameters can comprise fusing said first and second belief of identity values. The analysis of the first and second parameters can comprise determining a probability of the vehicle user being one of said plurality of candidates. The determined probability can be compared to a predetermined belief (certainty) threshold, the vehicle user being identified if the determined probability exceeds said predetermined belief threshold.

The fusion algorithm can be run in an iterative mode until the determined probability is equal to or greater than the predetermined belief threshold. The self-learning algorithm can comprise biometrics data for the user, for example physiological and/or behavioural biometrics data and/or usage analytics. The information can be segmented and each segment considered as the node to be fused.

The method can analyse more than two parameters, for example parameters acquired from other nodes. Thus, the method can be implemented with a degree of redundancy whereby the analysis can be performed even if one node fails.

The first parameter and/or the second parameter can comprise physiological biometric data relating to the vehicle user. The physiological biometric data can comprise one or more of the following: fingerprint data for the vehicle user; voice recognition data for the vehicle user; face recognition data for the vehicle user; and weight data of the vehicle user.

The first parameter and/or the second parameter can comprise behavioural biometric data relating to the vehicle user. The behavioural biometric data can measure how the vehicle user interacts with one or more vehicle systems. The behavioural biometric data can be derived directly or indirectly from vehicle systems, for example by monitoring one or more sensors or monitoring one or more user requests. The behavioural biometric data can relate to one or more of the following: a time period that at least one vehicle door remains open; a sequence in which one or more vehicle systems are activated; and a selected setting of one or more vehicle systems.

The first parameter or the second parameter can relate to depression of a vehicle control pedal. The vehicle control pedal can be a brake pedal or a clutch pedal. The vehicle control pedal can, for example, be applied as part of a start-up procedure, for example during an engine start-up procedure, and/or to release a parking brake. By way of example, the method can comprise monitoring the vehicle user depressing a vehicle clutch pedal in a manual vehicle during an engine start-up procedure; or monitor depressing a foot brake in an automatic vehicle during an engine start-up procedure. Alternatively, or in addition, the method can comprise monitoring the vehicle user depressing a brake pedal, for example to release an automated parking brake. The method can comprise the first parameter or the second parameter relates to one or more of the following: a travel range of the vehicle control pedal; a pressure applied to the vehicle control pedal; a rate of application of the vehicle control pedal; a time period during which the vehicle control pedal is applied.

The depression of the vehicle control pedal could be monitored directly, for example using a transducer coupled to the vehicle control pedal. Alternatively, the depression of the vehicle control pedal could be monitored indirectly by monitoring the vehicle system associated with the vehicle control pedal. For example, the depression of the brake pedal could be monitored with reference to a pressure in a hydraulic braking system coupled to the brake pedal.

The term node used herein can refer to a system timer, a sensor or an input device. The first node can be a primary node or a secondary node. The second node can be a primary node or a secondary node. The term primary node is used herein to refer to a node which is capable of providing a conclusive identification of the individual; and the term secondary node is used herein to refer to a node incapable of providing a conclusive identification of the individual.

The method can comprise implementing a learning phase during which reference data is generated for each vehicle user having a stored user profile. The generated reference data could optionally be stored in the user profile.

The first node or the second node can be configured to identify a key fob used to control a vehicle system. The first parameter or the second parameter can relate to historical usage of the key fob. The historical key fob usage can, for example, comprise data indicating which individual previously used the key fob to control a vehicle system. The method can comprise determining a likelihood of a particular individual being associated with the key fob in dependence on said historical usage data. The method can comprise updating the historical data following identification of the vehicle user.

The first node or the second node is configured to identify a cellular telephone coupled to a vehicle system and to determine historical usage of the cellular telephone. The first parameter or the second parameter can relate to historical usage of the cellular telephone. The historical telephone usage can, for example, comprise data indicating which individual is associated with the cellular telephone. The method can comprise determining a likelihood of a particular individual being associated with the cellular telephone in dependence on said historical usage data. The method can comprise updating the historical data following identification of the vehicle user.

According to a further aspect of the present invention there is provided a vehicle control apparatus for identifying a vehicle user associated with one of a plurality of stored user profiles, the apparatus comprising a processor configured to:

acquire at least first and second parameters, the first parameter being acquired from a first node at a first time, and the second parameter being acquired from a second node at a second later time;

perform first analysis of at least said first parameter, before the second time, to identify the vehicle user; and

perform second analysis of at least said second parameter to identify the vehicle user.

The first analysis can comprise determining a first probability of the vehicle user being associated with one of said stored user profiles. The processor can be configured to update the first probability with a result of the second analysis to determine a second probability of the vehicle user being associated with one of said stored user profiles.

Updating the first probability with the result of the second analysis can be in dependence on a conflict condition associated with the second parameter. The first probability may not be updated if the first analysis and the second analysis identify different vehicle users. Conveniently, parameters from unreliable nodes may be discarded.

The second probability may be compared to a predetermined belief threshold, the vehicle user being identified if the determined probability exceeds said predetermined belief threshold.

Subsequent to performing said second analysis, the processor can be configured to repeat the operations after a delay or if a condition associated with a change of vehicle user is satisfied.

The first parameter and/or the second parameter can comprise physiological biometric data relating to the vehicle user. The physiological biometric data can comprise one or more of the following: fingerprint data for the vehicle user; voice recognition data for the vehicle user; face recognition data for the vehicle user; and weight data of the vehicle user.

The first parameter and/or the second parameter can comprise behavioural biometric data and/or usage data relating to the vehicle user. The behavioural biometric data relates to one or more of the following: a time period that at least one vehicle door remains open; a sequence in which one or more vehicle systems are activated; and a selected setting of one or more vehicle systems; a seat position; seat movement; seatbelt length.

The first parameter or the second parameter can relate to depression of a vehicle control pedal. The first parameter or the second parameter relates to one or more of the following: a travel range of the vehicle control pedal; a pressure applied to the vehicle control pedal; a rate of application of the vehicle control pedal; a time period during which the vehicle control pedal is applied. The vehicle control pedal can be a brake pedal or a clutch pedal.

The first node can be a primary node or a secondary node. The second node can be a primary node or a secondary node.

The processor can be configured to implement a learning phase during which reference data is generated for each vehicle user having a stored user profile.

The first node or the second node can be configured to identify a key fob used to control a vehicle system. The first parameter or the second parameter can relate to historical usage of the key fob. The historical usage data can comprise one or more of the following: which user is associated with a particular key fob; how often each user uses the key fob; the time of day when each user uses the key fob. The processor can be configured to analyse the historical usage data to determine probability information. In particular, the processor can be configured to determine the probability of a candidate user being associated with the key fob based on the current use of the key fob.

The first node or the second node can be configured to identify a cellular telephone coupled to a vehicle system and to determine historical usage of the cellular telephone. The first parameter or the second parameter can relate to historical usage of the cellular telephone. For example, a particular user may be associated with the identified cellular telephone. The processor can be configured to analyse the historical usage data to determine probability information. In particular, the processor can be configured to determine a probability of a candidate user being associated the cellular telephone.

According to a further example of the present invention there is provided a method of identifying a vehicle driver associated with one of a plurality of stored user profiles, the method comprising:

acquiring one or more parameters relating to depression of a vehicle control pedal; and

analysing said one or more parameters to identify the vehicle driver. The depression of the vehicle control pedal can be used to generate said one or more parameters which can be used to identify the vehicle driver. In particular, the vehicle driver is identified from a plurality of candidate drivers each having a stored user profile. This technique is believed to be patentable independently. In certain embodiments, the vehicle driver could be identified based exclusively on the acquired parameter(s) relating to depression of the vehicle control pedal. Thus, the vehicle control apparatus can identify the vehicle driver exclusively based on said one or more parameters acquired in relation to depression of the vehicle control pedal. This is believed to be patentable independently of the other concepts described herein. The method can consist of acquiring said one or more parameters and analysing said one or more parameters to identify the vehicle driver.

The acquired parameter(s) can relate to one or more of the following:

a travel range of the vehicle control pedal;
a pressure applied to the vehicle control pedal;
a rate of application of the vehicle control pedal; and
a time period during which the vehicle control pedal is applied.

The analysis can comprise classifying the acquired parameter(s) in dependence on one or more predefined thresholds. The analysis can comprise determining probability information based on the classification of the acquired parameter(s). The probability information can be determined in dependence on stored usage data. The stored usage data can, for example, comprise data establishing a relationship or correlation between the acquired parameter(s) and the candidate drivers.

The vehicle control pedal can be a brake pedal. The brake pedal can be depressed during a vehicle start-up procedure; or during a procedure to release a parking brake.

Alternatively, the vehicle control pedal can be a clutch pedal. The clutch pedal can be depressed during a vehicle start-up procedure.

According to a further example of the present invention there is provided a vehicle control apparatus for identifying a vehicle driver associated with one of a plurality of stored user profiles, the apparatus comprising a processor configured to:

acquire one or more parameters relating to depression of a vehicle control pedal; and

analyse said one or more parameters to identify the vehicle driver.

In certain embodiments, the vehicle driver could be identified based exclusively on the acquired parameter(s) relating to depression of the vehicle control pedal. Thus, the vehicle control apparatus can identify the vehicle driver exclusively based on one or more parameters acquired in relation to depression of the vehicle control pedal. This is believed to be patentable independently of the other concepts described herein.

The acquired parameter(s) can relate to one or more of the following:

a travel range of the vehicle control pedal;

a pressure applied to the vehicle control pedal;

a rate of application of the vehicle control pedal; and

a time period during which the vehicle control pedal is applied.

The processor can be configured to classify the acquired parameter(s) in dependence on one or more predefined thresholds.

The processor can be configured to determine probability information based on the classification of the acquired parameter(s). The probability information can be determined in dependence on stored usage data.

The vehicle control pedal can be a brake pedal. The processor can be configured to acquire said one or more parameters during a vehicle start-up procedure; or during a procedure to release a parking brake.

The vehicle control pedal can be a clutch pedal. The processor can be configured to acquire said one or more parameters during a vehicle start-up procedure.

The method(s) described herein is/are machine-executable, for example on a computational device. According to a further aspect of the present invention there is provided a computer program which, when run on a processor, causes one or more of the methods described herein to be performed.

The term processor is used herein to refer to an electronic processor (singular or plural). The processor can be coupled to system memory comprising one or more memory devices. The processor is programmable to read a set of software instructions which, when executed, cause the processor to implement the method(s) described herein. The software instructions can be supplied on a non-transitory machine-readable medium or a machine-readable signal.

According to a further example of the present invention there is provided a method of identifying a vehicle user associated with one of a plurality of stored user profiles, the method comprising:

acquiring at least first and second parameters, the first parameter being acquired from a first node, and the second parameter being acquired from a second node; and

analysing at least said first and second parameters to identify the vehicle user. A user profiles is stored for each user associated with the vehicle. By identifying the vehicle user, the appropriate user profile can be selected, for example to configure or to control one or more vehicle systems based on user preferences. The method can be used to predict and recognize the user. The method can augment a less accurate identification system for more accurate performance. The method can improve the level of belief of identity by analysing said first and second parameters based on Bayesian Theory. The method can utilise data fusion techniques, for example in the form of a fusion algorithm, to fuse the information coming from the first and second nodes. The vehicle user is typically a driver of the vehicle, but could another vehicle user, such as a passenger.

According to a further example of the present invention there is provided a vehicle control apparatus for identifying a vehicle user associated with one of a plurality of stored user profiles, the apparatus comprising a processor configured to:

acquire at least first and second parameters, the first parameter being acquired from a first node, and the second parameter being acquired from a second node; and

to analyse at least said first and second parameters to identify the vehicle user. A plurality of candidate users can be identified based on the stored user profiles. The processor can be configured to identify the vehicle user from said plurality of candidate users.

Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination, unless such features are incompatible. The applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

BRIEF DESCRIPTION OF THE DRAWINGS

One or more embodiments of the present invention will now be described, by way of example only, with reference to the accompanying figures, in which:

Figure 1 shows a schematic of an automated user recognition system in accordance with an embodiment of the present invention

Figure 2 shows a first flow diagram illustrating operation of the automated user recognition system shown in Figure 1;

Figure 3 shows a second flow diagram illustrating the operation of the automated user recognition system during a learning phase;

Figure 4A shows a first schematic representation of the acquisition of data from the nodes in the automated user recognition system shown in Figure 2;

Figure 4B shows a second schematic representation of the acquisition of data from the nodes in the automated user recognition system shown in Figure 2;

Figure 4C shows the serial analysis of the nodes shown in Figure 2A in one implementation of the present invention;

Figure 5 shows a third flow diagram illustrating the operation of the automated user recognition system;

Figure 6 shows a fourth flow diagram illustrating the operation of the automated user recognition system;

Figure 7 shows a fifth flow diagram illustrating the operation of the automated user recognition system;

Figure 8 shows a sixth flow diagram illustrating the operation of the automated user recognition system;

Figure 9 shows a seventh flow diagram illustrating the operation of the automated user recognition system;

Figure 10 shows a plot used for nearest neighbour analysis of the data received from the nodes;

Figure 11 shows a first graph illustrating the variations in the measured time from the driver door opening to engine start-up for different users;

Figure 12 shows a second graph illustrating the variations in the maximum applied pressure during a start-up procedure for different users; and

Figure 13 shows a third graph illustrating the variations in the time before brake pedal activation for different users.

DETAILED DESCRIPTION

An embodiment of a control apparatus in the form of an automated user recognition (AUR) system 1 for a vehicle V will now be described with reference to the accompanying figures. The AUR system 1 is operable to identify a vehicle user from a plurality of candidate users associated with that vehicle V. The candidate users in the present embodiment are identified with reference to stored user profiles. The user is typically a driver of the vehicle, but the AUR system 1 is not limited in this respect and can be used to identify other vehicle users. The AUR system 1 identifies the user based on a combination of physiological biometrics and/or behavioural biometrics and/or usage analytics.

As shown in figure 1, the AUR system 1 comprises a processor 3 coupled to system memory 5. The processor 3 is configured to execute a set of software instructions held in the system memory 5 to implement a self-learning algorithm in accordance with an aspect of the present invention. The processor 3 is coupled to a communication bus 7, such as a CAN bus, to acquire inputs from a plurality of vehicle systems. The processor 3 is configured to perform statistical analysis of the data received from the vehicle systems to identify the user. The system inputs from the vehicle systems comprise signals from a plurality of vehicle sensors 9A-E which, as described herein, convey primary and secondary parameters relating to the user. The vehicle sensors 9A-E include: a door state sensor 9A, a seatbelt sensor 9B, a driver seat position and/or seat movement sensor 9C, a brake/clutch pedal pressure sensor

9D and one or more weight sensors 9E(which can be provided on the driver and passenger-side seats) and a seatbelt length sensor. System inputs can also include user inputs, for example from a user interface 11. In addition, a sensor can be disposed on the steering wheel, for example a pressure sensor or a capacitive sensor for determining a holding pattern, an electrocardiogram (ECG) sensor for detecting cardiac rhythm.

Furthermore, the processor 3 is coupled to a vehicle infotainment AUR system 13 for establishing a wireless coupling with a cellular telephone 15. Each user profile is associated with one or more cellular telephones 15 and, by identifying the cellular telephone 15 coupled to the vehicle infotainment AUR system 13, the processor 3 can derive a parameter for identifying the user. The identification of the cellular telephone 15 can be based on a user-specified name or the default device name which will be mapped to the user profile while creation of profile or while adding a new personal device (for example, a telephone, tablet computer or personal computer) to the profile. The processor 3 is also connected to a vehicle access AUR system 17 for communicating wirelessly with a key fob 19 to control vehicle systems, including locking/unlocking vehicle doors and controlling the ignition. There are several key fobs 19 associated with the vehicle V and, by identifying which key fob 19 is used to unlock the vehicle doors, the processor 3 can derive an additional parameter for identifying the user. It will be appreciated therefore that identification of the cellular telephone 15 and/or the key fob 19 generates parameters to facilitate identification of the user.

An overview of the operation of the AUR system 1 is provided in a first flow chart 100 shown in Figure 2. Communication is established between the key fob 19 and the vehicle V (step 103). Upon authentication of the key fob 19 by the vehicle access AUR system 17, one or more doors of the vehicle V are unlocked (step 105). A wireless coupling is established between the cellular telephone 15 and the vehicle infotainment AUR system 13 (step 107), for example over a Bluetooth® network. The vehicle infotainment AUR system 13 is activated (step 109) and the cellular telephone 15 is identified. As described herein, the cellular telephone 15 and the key fob 19 can independently or in combination provide parameters for identifying the user (step 111). The engine of the vehicle V is started (step 113) using a standard control strategy requiring that a starter button is actuated whilst the user depresses the brake pedal (for an automatic vehicle) or the clutch (for a manual vehicle).

A pre-processing operation (step 115) is performed based on system inputs received by the processor 3 from the vehicle sensors 9A-E. The door state sensor 9A outputs a status of each door in the vehicle (opened/closed) (step 117). The seatbelt sensor 9B outputs a signal indicating the status of each seatbelt in the vehicle (fastened/unfastened) (step 119). The driver seat position and/or seat movement sensor 9C outputs a signal indicating seat movement/position (moving/not moving and/or value of the position) (step 121), for example based on selection of a pre-set seat position. A brake/clutch pedal sensor 9D outputs a signal comprising the pressure applied to the brake/clutch pedal during the start-up procedure (step 123). The driver and/or passenger weight sensor 9E outputs a signal indicating the status of each passenger weight sensor 9E (i.e. to determine whether a passenger is present/not present) (step 125). The vehicle sensors 9A-E output raw data which is analysed by the processor 3. The pre-processing operation (step 115) can analyse timings (such as the period of time that a vehicle door is opened; operating sequences and so on) were meant to be calculated in the 115 block. As described herein, the signals received from the vehicle sensors 9A-E are subject to statistical analysis by a prediction algorithm (step 127) to determine a probability of the user being one of a plurality of candidate users associated with the vehicle V (step 129). A first driver identification can be generated based on the determined probability information. In parallel, the AUR system 1 can cross-reference historic data associated with the identified cellular telephone 15 and usage of the key fob 19 to generate a second driver identification (step 131). The first and second driver identifications can be compared to identify potential conflicts, as described herein. The identified user is displayed for confirmation by the driver (step 133), for example via the user interface 11. Alternatively, or in addition, the vehicle V can comprise a biometric sensor, such as a fingerprint sensor or a face recognition system, to confirm the identification of the driver.

The confirmation of the identity of the driver has particular application during a learning (training) phase when the AUR system 1 learns characteristics associated with each candidate user of the vehicle V. During the learning phase, the signals received from the vehicle sensors 9A-E can be stored for future reference. The driver identification parameters can be updated upon receipt of confirmation of the driver (step 135). Also, the driver identification data can be input to the prediction algorithm (step 137) to provide improved predictions.

The implementation of the AUR system 1 will now be described in more detail. The processor 3 is configured to execute software which implements a self-learning algorithm. The processor 3 accesses files stored in a database for each user having a stored user profile. The files associated with each user profile comprise parameters relating to that user’s usage of the vehicle systems. To facilitate timely identification of the user, the parameters are typically associated with the behaviour of the user as they enter the vehicle

V and/or during a start-up procedure and/or during release of a parking brake. The records can also comprise parameters derived from the signals generated by the vehicle sensors 9A-E.

As outlined above, the AUR system 1 undergoes a learning phase for each user profile (for example, an initial period of 30 days following addition of a new user profile). During the learning phase, the user is asked to select their profile before driving the vehicle V. If the vehicle V comprises a biometric sensor, this can be used to identify the user during the learning phase. The learning phase allows the processor 3 to identify behavioural and physiological biometric parameters associated with a particular user in order to enable that user to be identified.

A second flow chart 200 is shown in Figure 3 to illustrate the learning phase implemented by the processor 3. The user is identified using a biometric sensor or by the user selecting their user profile (step 201). The processor 3 collects data relating to one or more vehicle systems and the data is segmented (step 203). The processor 3 then performs statistical analysis on the segmented data and updates the stored statistical data (step 205). This cycle is repeated throughout the learning phase (operation 207). In the present embodiment, the learning phase can be performed for a finite period of time, for example a period of 30 days following creation of a new user profile. Alternatively, the learning process can be performed continuously. In a continuous configuration, the automatic identification of the user can be disabled for an initial (predefined) period of time following creation of a new user profile.

In the present embodiment, the processor 3 seeks to differentiate between users associated with the vehicle V by analysing a plurality of parameters relating to a user when they interact with the vehicle. These parameters can comprise physiological biometric data and/or behavioural biometric data. As illustrated in Figure 4A, the processor 3 is configured to receive data from the vehicle sensors 9A-E and also from biometric systems, such as one or more of the following: a face recognition system, a fingerprint recognition system and a voice (speaker) recognition system. As shown in Figure 4B, the system can comprise identification nodes corresponding to physiological biometrics, behavioural biometrics and usage analytics; for identifying a user it uses the nodes whatever is available at that point of time. The processor 3 can also receive location data and/or journey data from an integrated satellite navigation system (not shown). The various parameters considered by the processor 3 will now be described with reference to four users (John, Jessica, JM and Jack) each having a user profile associated with the vehicle V.

FACE RECOGNITION (NODE 1)

The processor 3 stores a face template of each user. The driver facing camera captures image data including a sample of the user's face and this is compared with the stored face template. The processor 3 accesses the user statistics for further processing.

FINGERPRINT RECOGNITION (NODE 2)

The processor 3 stores a fingerprint template of each user. A fingerprint sensor can be provided to capture a fingerprint sample. The fingerprint sensor can, for example, be disposed on a door handle or a start-stop engine button. The captured fingerprint sample can be compared with the stored fingerprint template. The processor 3 accesses the user statistics for further processing.

VOICE RECOGNITION (NODE 3)

The processor 3 stores a voice template of each user. A microphone captures a voice sample from the user. The captured voice sample is compared with the stored template. The processor 3 accesses the user statistics for further processing.

CARDIAC RHYTHM (NODE 4)

The processor 3 stores a cardiac rhythm template of each user. A cardiac rhythm sensor is provided, for example in the steering wheel, to capture a cardiac rhythm sample. The captured cardiac rhythm sample is compared with the stored template. The processor 3 accesses the user statistics for further processing.

CELLULAR TELEPHONE OR PERSONAL DEVICE (NODE 5)

The processor 3 stores identification information for a personal device such as phone, Tablet PC, personal laptop computer, or any other personal device which can be wirelessly coupled with the vehicle. The device(s) are mapped to user profiles. Users can be identified when the system identifies one or more of said devices.

KEY FOB USAGE (NODE 6)

The processor 3 stores the usage data relating to usage of the key fob by each user. A vehicle may have more than one (1) key fob. The system identifies the key fob that has been used, for example to access the vehicle V. The usage statistics of that particular key fob are used by the processor 3 for further processing.

LOCATION (GPS DATA) (NODE 7)

The processor 3 stores location information of the vehicle V. The system identifies the location based on GPS data.The statistics of usage by different users for an identified vehicle location are used by the processor 3 for further processing.

WEIGHT OF THE USER (NODE 8)

The processor 3 can generate and maintain a record of the weight of the users. In the present embodiment, there are six predefined weight bands W1-6 and the processor 3 categorises each user in one of the weight bands W1-6. By way of example, the processor 3 can keep the record as shown below:

Fourth Weight Band W4: JM – 11%, Jessica – 80%, Guest – 9%
Fifth Weight Band W5: JM – 69%, Jessica – 20%, Guest – 11%

These statistics represent the percentage of the users found in the fourth and fifth weight bands W4, W5 respectively. So if the processor 3 determines that a user in the vehicle V belongs in the fifth weight band W5, the statistics are output for the fifth weight band W5. Upon successful identification of the user (either using the techniques described herein or during the learning phase) the processor 3 will update the weight band for that user.

HEIGHT (NODE 9)

The processor 3 can generate and maintain a record of the height of the vehicle users. For example, there could be six predefined weight bands H1-6 and the processor 3 can categorise each user in one of the height bands H1-6. The height of the user could be based on image processing of a driver-facing camera.

DAY AND TIME OF USAGE (NODE 10)

The processor 3 generates and maintains temporal data, including the weekday and/or time, relating to usage of the vehicle V. The temporal data is collated for each user using the vehicle V. For example, if the processor 3 determines that the vehicle V is being used on a Wednesday morning, the processor 3 will access the statistical data identifying which users used the car on Wednesday morning. The statistical data can for example specify:

Wednesday Morning: John – 77%, JM – 20, Jessica 3%

In order to generate the temporal data, the processor 3 segment each day and keeps a record of vehicle usage during each segment.

STEERING WHEEL HOLDING PATTERN (NODE 11)

The processor 3 can look at other patterns, such as a steering wheel holding pattern. A pressure sensor or a capacitive sensor can be provided in the steering wheel to determine the position of the driver's hands on the steering wheel of the vehicle V. The resulting positional data can be compared to historical data to identify the user. In addition to using positional data, a measured pressure pattern could be measured and compared with stored patterns to identify the user.

BRAKE/CLUTCH USAGE PATTERN (NODE 12)

The depression of the vehicle control pedal could be monitored directly, for example using a transducer coupled to the vehicle control pedal. Alternatively, the depression of the vehicle control pedal could be monitored indirectly by monitoring the vehicle system associated with the vehicle control pedal. For example, the depression of the brake pedal could be monitored with reference to a pressure in a hydraulic braking system coupled to the brake pedal. The statistics of users based on the pressure value is provided for further processing to identify the vehicle users.

DRIVER DOOR TO ENGINE START TIME (NODE 13)

The processor 3 measures and stores time information relating to the time elapsed from the opening of a driver door to the engine start time for different vehicle users. Based on the timing from the historical data the user statistics are provided for further processing to identify the vehicle user.

MEMORY SWITCH USAGE (NODE 14)

A plurality of memory switches are provided to enable a user to select a programmable seat position. The processor 3 stores a record of which memory switch is pressed by a user. For example, the vehicle V may comprise six memory switches M1-6 which can each be associated with a particular user profile. If the user doesn't use a memory switch, the processor 3 can attempt to match the current settings to the saved settings. For example, if the user does not use a memory switch but the processor 3 determines that the current settings match or substantially match the second memory switch M2, then the user is categorized as the user associated with the corresponding user profile. The processor 3 can access statistics derived from historic usage of the memory switches M1-6 for each user. The memory switch M1-6 associated with each user can, for example, be determined during the learning phase. Thus, if a user gets into the vehicle V and presses the second memory switch M2, the processor 3 will provide the user statistics associated with the second memory switch M2. By way of example, the user statistics could be as follows:

Second memory switch M2 usage: Jessica - 80%, JM- 20%

JOURNEY INFORMATION (NODE 15)

The processor 3 maintains a record of the driver using the vehicle V for an outward journey (for example, away from a home location, or use of the vehicle V in the morning) and a return journey (for example, towards a home location, or use of the vehicle V in the evening). The processor 3 determines that the same driver for the return journey will be the same as the driver for the outward journey. The processor 3 generates and maintains a record of the driver for the outward journey and modifies the statistics for the return journey. The processor 3 can be configured to determine if the journey is a return journey, for example by communicating with a satellite navigation system (not shown) to identify a journey destination.

SEQUENCE OF OPERATION OF VEHICLE SYSTEM (NODE 16)

The processor 3 learns and stores information on usage of vehicle system such as timing and sequence of usage of seat belt or any specific switches. Based on the timing and sequence a statistical analysis can be performed and matching statistics can be retrieved from the historical data. The statistics can be provided for further processing to identify the vehicle users.

The parameters each correspond to an event. It will be appreciated that each event can correspond to a sensor measurement, a control signal, for example transmitted over the CAN bus. A probability is associated with that event. In the context of the present application, the probability provides an indication of the likelihood of that event correctly identifying the user. The probability is defined herein as a percentage (%) and the value associated with each event is referred to as a Belief of identity (BOI) value. By combining, or fusing, the BOI value for a plurality of events, the processor 3 can determine a cumulative System Belief of identity (SBOI) based on two or more parameters. The AUR system 1 is a multimodal identification approach. At system level each mode is represented as an identification node. Each of the nodes has a belief attached (the BOI value) as to the identity of the driver. The data is fused at a high level (also referred to as decision level fusion. The SBOI can be compared to a predefined belief threshold to identify the user of the vehicle V from a plurality of candidates. A diagram representing the serial consideration of a sample set of six parameters is shown in Figure 4C, each of the corresponding six events is represented by a corresponding node N1-6.

The nodes are further classified to determine how the related BOI values are fused. In the present embodiment, the nodes are classified as either primary nodes or secondary nodes. Those nodes which are capable independently of identifying the user are classed as primary nodes. Nodes corresponding to physiological biometric sensor (such as face, fingerprint, voice and cardiac rhythm) can be classed as primary nodes, with the exception of weight and height which are generally classified as soft biometrics. By way of example, a biometric sensor could identify the user and is, therefore, considered a primary node. The identification of personal devices, such as the coupling of the cellular telephone 15 to the infotainment AUR system 13, can also be used to identify the user and, therefore, is considered a primary node. Other forms of personal devices include a tablet computer, a personal computer or any wireless device which can be coupled with the vehicle V to enable the vehicle V to identify the device which is mapped with the user profile. The nodes which are incapable of conclusively identifying the user are referred to herein as secondary nodes. Secondary nodes are the nodes which are associated with behavioural biometrics and/or usage analytics, such as one or more of the following: day of week and time based usage, key fob usage, cellular telephone usage, location based usage, memory switch usage, steering wheel holding pattern, brake/clutch pressure values, time period from opening driver door to engine start time, sequence of operation of vehicle systems.

As a user gets into the vehicle V with the key fob 19, the processor 3 allocates a prior probability based on the number of users associated with the vehicle. The number of users can be derived from the input user profiles and/or from the learning procedure. If the number of users associated with the vehicle V is five (5), a prior probability of 20% is allocated. It will be appreciated that the prior probability depends on the number of users using a particular keyfob. The prior probability value is acquired from the historical self-learning data and is set based on the historical data of keyfob usage. As data is acquired for a particular node, the BOI value for that node is considered for fusing with the BOI value for another node. A fusing algorithm, such as a Bayesian algorithm, is used to fuse the BOI values from two or more nodes. Other fusing techniques, such as Dempster–Shafer theory or Kalman filter, could also be used. A posterior probability is thus obtained. The posterior probability is the fusion result which corresponds to an improved SBOI. An interim SBOI can be improved by fusing other available nodes. The final SBOI is obtained after combining all the available nodes. The hypothesis of a candidate being the driver is improved from the prior probability based on the BOI values obtained for several nodes. The fusing of the BOI values for nodes is carried out iteratively until the posterior probability is equal to or greater than a predefined Belief Threshold (BT). In the present embodiment, the BT is set as 99%, provided the nodes are available. If the posterior probability reaches 99% the profile of the user is identified and the appropriate user profile can be loaded automatically. If the probability is less than 99%, then the system can suggest the most likely profile (or profiles) to facilitate selection of the appropriate user profile by the driver. It will be appreciated that the BT is not fixed at 99% and other values can be implemented.

The processor 3 implements a selective strategy for fusing the BOI values for separate nodes based on whether they are classified as primary or secondary nodes. If a primary node exists, each additional node can be considered as a secondary node. The fusion of primary and secondary nodes is performed separately. If the primary node has failed or doesn't exist, the secondary nodes fusion result provide the SBOI value. The operation of the AUR system 1 will now be described with reference to the third flow chart 300 shown in Figure 5. If a primary node is identified, the BT is set at 60%, otherwise the BT is set as 99%.

A check is performed to determine which nodes are active. The processor 3 identifies two secondary nodes to be fused based on the active nodes (step 301). A BOI value of the secondary nodes is retrieved (step 303) and, if present, the primary node is fused (step 305). The BOI value of the secondary node is fused to get the resultant BOI value (step 307). A check is performed to determine if the BOI value is greater than a belief threshold (step 309). If not, a check is performed to determine if any other secondary node exists (step 311). If other secondary nodes exist, the BOI value for those node(s) is retrieved (step 313). If there are no other secondary nodes, the most likely probably profile for the user is selected (step 315). If the comparison of the calculated BOI value and the belief threshold (step 309) determines that the calculated BOI value is greater than the belief threshold, a check is performed to determine if a primary node exists or the belief is checked (step 317) The secondary result is considered to be the system belief (step 319), thereby providing a fail-safe strategy for handling a failure mode of the primary node. The secondary result is then used to identify the user (step 321). If the check determines that the primary node exists (step 317), a check is performed to determine if the same user is identified by said primary and secondary nodes (step 323). The primary and secondary results are fused to provide improved accuracy (step 325). The user is identified based on the fused results (step 321).

The operation of the processor 3 will be described in greater detail with reference to the flow charts shown in Figures 5 to 8. An overview of the process flow is shown in the fourth flow chart 400 shown in Figure 5. A user approaches the vehicle with the key fob 19 (step 401) and the vehicle access AUR system 17 identifies the key fob 19 and performs the appropriate authentication procedures. The processor 3 retrieves the usage statistic for the key fob 19 (step 403). The vehicle infotainment AUR system 13 identifies a cellular telephone 17 which is associated with one of the stored user profiles (step 405). The processor 3 determines when the user has opened the door and entered the vehicle V (step 407). The processor 3 then determines whether two primary nodes are available for fusing (step 409) and, if so, performs analysis based on the two primary nodes (step 411), as described herein with reference to the fifth flow chart 500 shown in Figure 6.

The analysis of the two primary nodes comprises an initial check to determine if the identities are the same for both of the primary nodes (step 501). If the identities are different, the nodes are ignored (step 503). If the identities are the same, a check is performed to determine if a fusion index is greater than one (1) (step 505). The fusion index is determined to check whether the fusion results in an improved BOI and can be considered as equivalent to the process gain. If the value is above 1 then the gain is positive otherwise it is negative. If the fusion index is greater than one (1), the gain is positive and the nodes are fused (step 507) with consideration being given to the proposition that all new evidence is false (step 509). If the fusion index is less than one (1), the gain is negative and the nodes are not fused, but if BOI of the node having the same identity is considerably high then prior BOI could be improved by an appropriate factor. A check is then performed to determine if any other nodes exist (step 511). If there are additional nodes, the procedure set out in the fifth flow chart 500 is repeated. If there are no other nodes, the fused data is returned to the fourth flow chart 400.

A check is performed to determine if the primary identity (i.e. the identity of the user determined by the primary nodes) is the same as the identity of the user associated with the identified cellular telephone 17 (step 413). If the identified user is the same, the processor 3 performs analysis based on two secondary nodes (step 415), as described herein with reference to the sixth flow chart 600 shown in Figure 7. The two secondary nodes are considered to determine if the secondary nodes are the same as the primary identity (step 601). The process set out in the fifth flow chart 500 is then repeated (step 603). The results of fusing the secondary nodes and the results of fusing the primary nodes are then fused following checking of the fusion index (step 605). A check is then performed to determine if the SBOI is greater than or equal to the defined BT (step 607). If the SBOI is larger than the BT, the processor 3 determines that the user has been identified (step 609). If the SBOI is less than the BT, the processor 3 performs initiates a voice (speaker) identification procedure (step 611) which is illustrated in a seventh flow chart 700 shown in Figure 8.

The voice (speaker) identification procedure is initiated by outputting an audio prompt to the user (step 701), for example outputting “Good Morning” via the vehicle infotainment AUR system 19. The voice identification procedure is initiated only when the final SBOI is below the BT. If the SBOI is above BT, the user is identified and the system will say “Good morning John <identified user name>”. The processor 3 detects a user response to the prompt via a microphone 21 disposed in the cabin of the vehicle V (step 703). The processor analyses the audio data to identify the speaker (step 705), for example with reference to voice recognition data associated with each user profile. A check is performed to determine whether the user identified using the voice recognition techniques is the same as the user identified through analysis of the primary and secondary nodes (step 707). If the identified users are not the same, the most probable result for the user to select is displayed (step 709). If the identified users are the same, a check is performed to determine if the fusion index is greater than 1 (step 711). If not, the most probable result for the user to select is displayed (step 709). If the fusion index is greater than 1, the nodes are fused (step 713) with consideration being given to the proposition that all new evidence is false (step 716). The node sometimes may have multiple beliefs with varying belief levels. For example, the statistics for the third node N3 are: John 80%, Jessica 3%, JM 7%, Jack 10%, but instead of considering only John for the third node N3 the AUR system 1 also consider other users. A check is then performed to determine if the SBOI is greater than or equal to the BT (step 717). If not, the most probable result for the user to select is displayed (step 709). If the SBOI is greater than or equal to the BT, the processor 3 determines that the user has been identified (step 719).

With reference to the fourth flow chart 400, if the primary identity is not the same as the identity of the user associated with the identified cellular telephone 17 (step 413), a dominant identity is identified in the secondary nodes (step 417). The dominant identity is the identity which has the highest number of identity among the secondary nodes. For example, if the AUR system 1 comprises twelve (12) secondary nodes and ten (10) of those nodes have identified John as the user and two (2) nodes have identified Jessica as the user, then the dominant identity is John. The identity of the user with the highest SBOI in the secondary nodes is identified (step 419). A secondary identity is finalized based on the dominant, highest and phone identity (step 421). The secondary identity is the collective identity of secondary nodes decided based on dominant, highest and phone identity .The processor 3 then considers two secondary nodes with the secondary identity (step 423) and the process outlined with reference to the fifth flow chart 500 shown in Figure 6 is repeated based on the secondary nodes (step 425).

A check is performed to determine if a primary node exists (step 427). If there is no primary node, the BT is changed (step 429), for example to increase BT from 60% to 99%. If there is a primary node, the fused secondary nodes are fused with the primary fused results after checking the fusion index (step 431). A check is performed to determine if the SBOI is above the BT (step 433). If so, the processor 3 identifies the user (step 435). If the SBOI is below the BT, the voice identification procedure is performed (Step 437), as described with reference to the seventh flow chart 709 shown in Figure 8.

As described herein, the processor 3 fuses the data from the primary and secondary. A working example based on Bayesian calculation of the BT will now be described. Consider the vehicle V is being used by four candidate users: John, Jessica, JM and Jack. The vehicle V has only one key fob 19 and in the present example has four (4) user profiles and one (1) guest profile. When a user gets into the vehicle V, the user profiles are presented for selection by the user. Profiles can be password protected if the user wishes to do so. The processor 3 executes the self-learning algorithm to list those profiles which are relevant. If the probability of correctly identifying the driver is high, then the system can directly load the profile or display the top 2 most probable profile along with the guest profile.

For the purpose of the present example, the self-learning algorithm has following data:

Vehicle usage percentage:

John	- 22%
Jessica	- 22%
JM	- 22%
Jack	- 22%
Guests	- 12%.

The BOI for the first node N1 (memory switch usage):

M1 : Jessica – 90%, Guests – 10%

M2 : John – 90%, Guests – 10%

M3 : JM – 45%, Jack – 45%, Guests – 10%

The probability of the driver being Jessica given that she uses a memory switch can be expressed as follow:

$$P(\text{Jessica}|\text{M1}) = \frac{P(\text{Jessica}) * P(\text{M1}|\text{Jessica})}{P(\text{Jessica}) * P(\text{M1}|\text{Jessica}) + P(\text{Others}) * P(\text{M1}|\text{Others}) + P(\text{John}) * P(\text{M1}|\text{John}) \ldots..}$$

$$P(\text{Jessica}|\text{M1}) = \frac{0.22 * 0.9}{0.22 * 0.9 + 0.12 * 0.1 + 0.22 * 0 \ldots..}$$

$$P(\text{Jessica}|\text{M1}) = 94.2\%$$

As seen the probability of the driver being Jessica is increased to 94.2% from the initial probability of 22%. Similarly the probabilities of the other users are:

$$P(\text{Jessica}|\text{M1}) = 94.2\%$$

$$P(\text{John}|\text{M2}) = 94.2\%$$

$$P(\text{JM}|\text{M3}) = 47.1\%$$

$$P(\text{Jack}|\text{M3}) = 47.1\%$$

The determined SBOI can be further improved by providing more than one key fob 19 in which case the prior probability would increase. Other parameters, such as the measured weight of the user (second node N2), can be used to improve the belief and to differentiate between the JM and Jack.

Supposing the users belongs to different weight band each with a respective probability, as set out in Table A below.

Weight Band		
61-63 Kg : W1	JM - 80%	Guests -20%
67-70 Kg: W3	John - 77%	Guests - 33%
74 – 76 Kg: W5	Jessica - 91%	Guests - 9%
80 – 83 Kg: W7	Jack - 95%	Guests - 5%

TABLE A

With this evidence, the SBOI gets updated to the following:

$$P(\text{Jessica}|\text{W5}) = 98.7\%$$

$$P(\text{John}|\text{W3}) = 94.8\%$$

$$P(\text{JM}|\text{W1}) = 94.01\%$$

$$P(\text{Jack}|\text{W7}) = 98.6\%$$

These are the probabilities of different users being the driver given that they use a particular memory switch and they belong to a particular weight band.

The probability can be improved above 99% with reference to data relating to the behavioural biometrics of each user. This algorithm would make a less efficient identification technology to work accurately.

It will be appreciated that other statistical analysis techniques can be employed to analyse the data from the primary and second nodes. The nodes can be fused using techniques other than Bayesian analysis. For example, analytical techniques such as clustering, fuzzy logic, Kalman filter, Demspster shafer, genetic algorithm and so on could be implemented.Rather than Bayesian analysis, the processor 3 could implement logistic regression or nearest neighbour (kNN) techniques. To implement logistic regression the parameters describing the model are modelled using a logistic function:

$$P = \frac{e^{a+bX}}{1+e^{a+bX}}$$

The nearest neighbour techniques can be used to identify the user based on the relationship between the nodes. The user is identified based on the node which is most common amongst its *k* nearest neighbours (where *k* is a positive integer). An exemplary plot 800 of nearest neighbour analysis based on brake pedal pressure and the time from when the driver opened the door to the engine start is shown in Figure 10. The brake pedal pressure is plotted on the X axis and the time from the moment the driver opened the door to engine start on the Y axis. The various points are measurements taken from three (3) identified drivers. The kNN algorithm, with k=4, is applied to determine the identity of the drivers from measurements represented by P1 and P2. The distances from points P1 and P2 to four (4) nearest points are calculated based on the pre-defined metric, such as Euclidean distance. The distance can be weighted, so that closest points are given higher priority to those lying further from the measurement. The outcome is the likelihood of point P1 and P2 belonging to a certain class (Driver 1, 2 or 3) based on the proximity of those classes. As shown in Figure 10, the algorithm classifies P1 as Driver 1 (three measurements classified as Driver 1 are in close proximity to P1 whilst only 1 measurement belongs to Driver 3) and it wouldn't classify P2 as the likelihood of that point belonging to any of the closest classes is too low (the distances are too similar).

The nearest neighbour analysis above relies on a measurement of the time period from the driver door opening to engine starting. A first graph 810 is shown in Figure 11 illustrating the variations in the measured time from the driver door opening to engine starting (shown on the Y axis) for a plurality of different users (shown on the X axis).

The depression of a vehicle control pedal, such as the vehicle brake pedal P, can be used to identify the user. It is envisaged that this would be performed during a start-up procedure for the vehicle V. For example, if the vehicle V has an automatic transmission, the vehicle start-up strategy requires that the foot brake is operated when the starter button is depressed. The processor 3 can be configured to monitor the operation of the vehicle brake pedal during this phase. The applied pressure can, for example, be derived from the measured pressure in the hydraulic braking system coupled to the brake pedal which is available from the CAN bus 7. The processor 3 can monitor one or more of the following: the maximum pressure applied by the user; the duration that the brake pedal is applied (for example the total time during which the brake pedal is applied, or the time after the engine has started); the rate at which the brake pedal is applied; and the time period elapsed before the brake pedal P is released once the engine is running.

During the learning phase, the processor 3 can determine the pressure applied to the brake pedal P by each user associated with the vehicle V. The processor 3 can determine an upper threshold and a lower threshold for at least one measured parameter for each user. For example, the processor 3 can determine upper and lower thresholds for each parameter.

The first graph 810 illustrates the variations in the measured time from the driver door opening to engine starting (shown on the Y axis) for a plurality of different users (shown on the X axis). A second graph 820 shown in Figure 12 illustrates the variations in the maximum pressure (Bar) applied (shown on the Y axis) for a plurality of different users (shown on the X axis). The maximum pressure applied can be measured during the learning phase to generate pressure data for each user. The pressure data collected can be analysed to define upper and lower pressure thresholds associated with each user. The upper and lower pressure thresholds can be used by the processor to identify which user is driving the vehicle V.

A third graph 830 shown in Figure 13 illustrates the variations in the time period (seconds) measured after the engine is running (shown on the Y axis) for a plurality of different users (shown on the X axis). The time period after the engine is running can be measured during the learning phase to generate time data for each user. The time data collected can be analysed to define upper and lower time thresholds associated with each user. The upper and lower time thresholds can be used by the processor to identify which user is driving the vehicle V.

The above techniques in relation to monitoring the depression of the brake pedal can also be used for a clutch pedal. In arrangements in which the vehicle V has a manual transmission, it is typical during the start-up procedure to require that the clutch is depressed. The techniques described herein could be applied to monitor the clutch pedal during this procedure. In addition, if the vehicle V has a button-operated parking brake, a safety strategy may require that the foot brake is depressed when the parking brake is released. The techniques described herein could be used to identify the driver whilst this operation is performed.

In some, but not necessarily all examples, the first parameter is acquired from a first node at a first time, at step 301. The second parameter is acquired from a second node at a second later time, referring to steps 311 and 313 to 307. First analysis of at least said first parameter is performed, before the second time, to identify the vehicle user, at step 303. The BOI of step 303 corresponds to a first probability. Second analysis of at least said second parameter is performed to identify the vehicle user, at step 313. The second analysis results in a BOI. At step 307, the fused SBOI corresponds to a second probability, wherein the second probability is calculated by updating the first probability with the result of the second analysis. The vehicle user is identified when the SBOI exceeds a predetermined belief threshold, at step 309. The first probability is updated in dependence on a conflict condition. In one embodiment, the first probability is not updated if the first analysis and the second analysis identify different vehicle users, at steps 501, 503. Conveniently, parameters from unreliable nodes may be discarded.

It should be appreciated that the described methods for identifying a user need not terminate when the vehicle user is identified. Instead, the methods may be repeated, optionally with a delay or condition, to check that the vehicle user is still the identified vehicle user. A condition may be a condition associated with a change of vehicle user. In some, but not necessarily all examples, the condition may comprise a threshold value or change for a parameter of a node. If the parameter value changes, thereby satisfying the condition, the identification methods may be repeated. A repetition of the methods may identify a different vehicle user when the SBOI of a different vehicle user exceeds the SBOI of the original vehicle user or exceeds a BT. An advantage is that a user's vehicle settings are not overwritten when the user switches with another vehicle user.

In some, but not necessarily all examples, the described methods determine which nodes regularly prove inaccurate for user identification, and subsequently these nodes are ignored in the described methods.

In some, but not necessarily all examples, the data generated during a learning phase or subsequently from on-going implementation of the method, may be transferrable from one vehicle to another vehicle. Similarly, the vehicle may receive pre-determined data and overwrite any existing data or default data with the new pre-determined data. An advantage is that a user may import their settings to different vehicles.

It will be appreciated that various changes and modifications can be made to the method(s) and apparatus described herein.

CLAIMS:

1. A method of identifying a vehicle user associated with one of a plurality of stored user profiles, the method comprising:

acquiring at least first and second parameters, the first parameter being acquired from a first node at a first time, and the second parameter being acquired from a second node at a second later time;

performing first analysis of at least said first parameter, before the second time, to identify the vehicle user; and

performing second analysis of at least said second parameter to identify the vehicle user.

2. A method as claimed in claim 1, wherein the first analysis comprises determining a first probability of the vehicle user being associated with one of said stored user profiles.

3. A method as claimed in claim 2, comprising updating the first probability with a result of the second analysis to determine a second probability of the vehicle user being associated with one of said stored user profiles.

4. A method as claimed in claim 3, wherein updating the first probability with the result of the second analysis is performed in dependence on a conflict condition associated with the second parameter.

5. A method as claimed in claim 3 or 4, wherein the first probability is not updated if the first analysis and the second analysis identify different vehicle users.

6. A method as claimed in any one of claims 3 to 5, wherein the second probability is compared to a predetermined belief threshold, the vehicle user being identified if the determined probability exceeds said predetermined belief threshold.

7. A method as claimed in any one of claims 1 to 6, wherein subsequent to performing said second analysis, the method of claim 1 is repeated after a delay or if a condition associated with a change of vehicle user is satisfied.

8. A method as claimed in any preceding claim, wherein the first parameter and/or the second parameter comprise physiological biometric data relating to the vehicle user.

9. A method as claimed in claim 8, wherein the physiological biometric data comprises one or more of the following:

a fingerprint data for the vehicle user;

a voice recognition data for the vehicle user;

a face recognition data for the vehicle user;

a weight data of the vehicle user; and

a cardio rhythm pattern of the vehicle user.

10. A method as claimed in any one of the preceding claims, wherein the first parameter and/or the second parameter comprise behavioural biometric data and/or usage data relating to the vehicle user.

11. A method as claimed in claim 10, wherein the behavioural biometric data and/or usage data relates to one or more of the following:

a time period that at least one vehicle door remains open;

a sequence in which one or more vehicle systems are activated and/or de-activated;

a selected setting of one or more vehicle systems;

usage of a cellular telephone or a personal device;

key fob usage;

location based identification;

weight based identification;

height based identification;

day and time based identification;

steering wheel holding pattern;

brake/clutch pressure value;

driver door to engine start time;

memory switch usage;

a seat position;

seat movement;

seatbelt length;

journey based identification; and

sequence of operation of vehicle systems.

12. A method as claimed in any one of the preceding claims, wherein the first parameter or the second parameter relates to depression of a vehicle control pedal.

13. A method as claimed in claim 12, wherein the first parameter or the second parameter relates to one or more of the following: a travel range of the vehicle control pedal; a pressure applied to the vehicle control pedal; a rate of application of the vehicle control pedal; a time period during which the vehicle control pedal is applied.

14. A method as claimed in claim 12 or claim 13, wherein the vehicle control pedal is a brake pedal.

15. A method as claimed in any one of the preceding claims, wherein the method comprises implementing a learning phase during which reference data is generated for each vehicle user having a stored user profile.

16. A method as claimed in any one of the preceding claims, wherein said first node or said second node is configured to identify a key fob used to control a vehicle system; the first parameter or the second parameter relating to historical usage of the key fob.

17. A method as claimed in any one of the preceding claims, wherein said first node or said second node is configured to identify a cellular telephone coupled to a vehicle system and to determine historical usage of the cellular telephone.

18. A computer program which, when run on a processor, causes the method of any one of claims 1 to 17 to be performed.

19. A vehicle control apparatus for identifying a vehicle user associated with one of a plurality of stored user profiles, the apparatus comprising a processor configured to:

acquire at least first and second parameters, the first parameter being acquired from a first node at a first time, and the second parameter being acquired from a second node at a second later time;

perform first analysis of at least said first parameter, before the second time, to identify the vehicle user; and

perform second analysis of at least said second parameter to identify the vehicle user.

20. A vehicle control apparatus as claimed in claim 19, wherein the first analysis comprises determining a first probability of the vehicle user being associated with one of said stored user profiles.

21. A vehicle control apparatus as claimed in claim 20, wherein the processor is configured to update the first probability with a result of the second analysis to determine a second probability of the vehicle user being associated with one of said stored user profiles.

22. A vehicle control apparatus as claimed in claim 21, wherein the processor is configured to update the first probability with the result of the second analysis in dependence on a conflict condition associated with the second parameter.

23. A vehicle control apparatus as claimed in claim 21 or 22, wherein the first probability is not updated if the first analysis and the second analysis identify different vehicle users.

24. A vehicle control apparatus as claimed in any one of claims 21 to 23, wherein the processor is configured to compare the second probability to a predetermined belief threshold, the vehicle user being identified if the determined probability exceeds said predetermined belief threshold.

25. A vehicle control apparatus as claimed in any one of claims 19 to 24, wherein subsequent to performing said second analysis, the processor is configured to repeat the operations of claim 19 after a delay or if a condition associated with a change of vehicle user is satisfied.

26. A vehicle control apparatus as claimed in any one of claims 19 to 25, wherein the first parameter and/or the second parameter comprise physiological biometric data relating to the vehicle user.

27. A vehicle control apparatus as claimed in claim 26, wherein the physiological biometric data comprises one or more of the following:

a fingerprint data for the vehicle user;
a voice recognition data for the vehicle user;
a face recognition data for the vehicle user;
a weight data of the vehicle user; and
a cardio rhythm pattern of the vehicle user.

28. A vehicle control apparatus as claimed in any one of claims 19 to 27, wherein the first parameter and/or the second parameter comprise behavioural biometric data and/or usage data relating to the vehicle user.

29. A vehicle control apparatus as claimed in claim 28, wherein the behavioural biometric data and/or usage data relates to one or more of the following:

a time period that at least one vehicle door remains open;
a sequence in which one or more vehicle systems are activated;
a selected setting of one or more vehicle systems;
usage of a cellular telephone or a personal device;
key fob usage;
location based identification;
weight based identification;
height based identification;
day and time based identification;
steering wheel holding pattern;
brake/clutch pressure value;
driver door to engine start time;
memory switch usage;
a seat position;
seat movement;
seatbelt length;
journey based identification; and
sequence of operation of vehicle systems.

30. A vehicle control apparatus as claimed in any one of claims 19 to 29, wherein the first parameter or the second parameter relates to depression of a vehicle control pedal.

31. A vehicle control apparatus as claimed in claim 30, wherein the first parameter or the second parameter relates to one or more of the following: a travel range of the vehicle control pedal; a pressure applied to the vehicle control pedal; a rate of application of the vehicle control pedal; a time period during which the vehicle control pedal is applied.

32. A vehicle control apparatus as claimed in claim 30 or claim 31, wherein the vehicle control pedal is a brake pedal.

33. A vehicle control apparatus as claimed in any one of claims 19 to 32, wherein the processor is configured to implement a learning phase during which reference data is generated for each vehicle user having a stored user profile.

34. A vehicle control apparatus as claimed in any one of claims 19 to 33, wherein said first node or said second node is configured to identify a key fob used to control a vehicle system; the first parameter or the second parameter relating to historical usage of the key fob.

35. A vehicle control apparatus as claimed in any one of claims 19 to 34, wherein said first node or said second node is configured to identify a cellular telephone coupled to a vehicle system and to determine historical usage of the cellular telephone.

36. A vehicle comprising the vehicle control apparatus claimed in any one of claims 19 to 35 or the computer program of claim 18.

37. A method or computer program substantially as herein described with reference to the accompanying figures.

38. A vehicle control apparatus substantially as herein described with reference to the accompanying figures.

39. A vehicle substantially as herein described with reference to the accompanying figures.

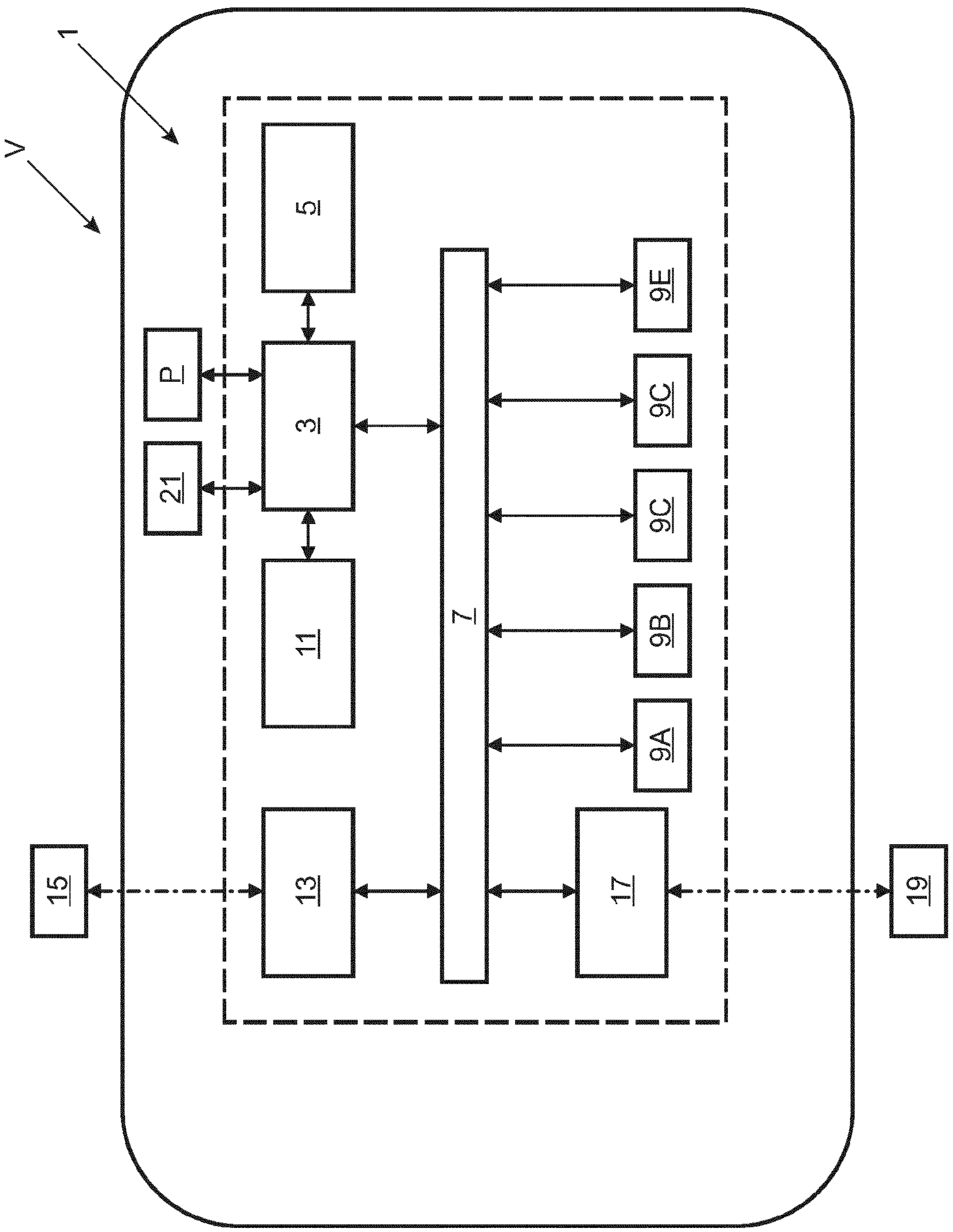

FIG. 1

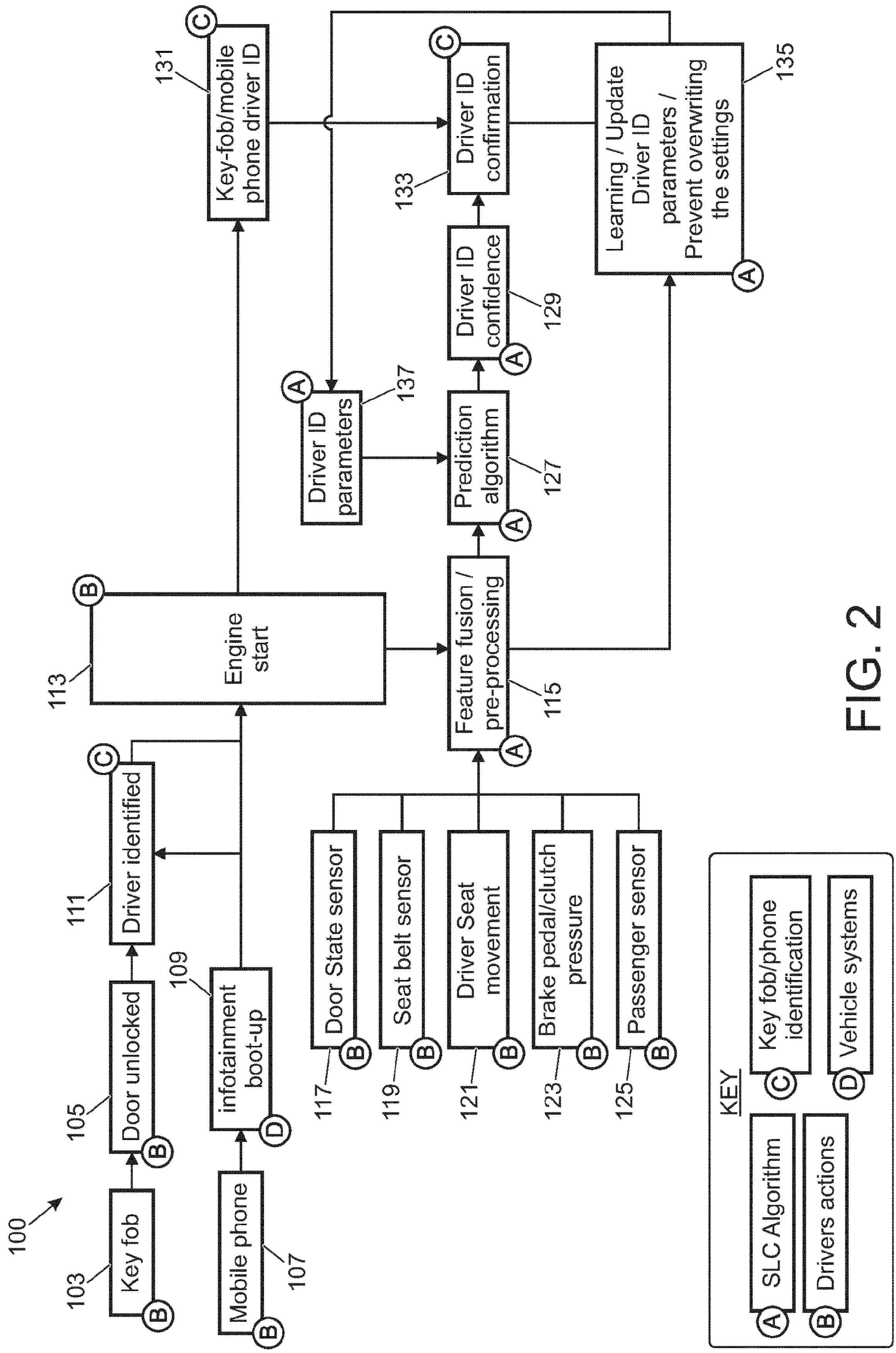
100
Key fob
103
Door unlocked
105
Mobile phone
107
infotainment boot-up
109
Driver identified
111
Engine start
113
Feature fusion / pre-processing
115
Door State sensor
117
Seat belt sensor
119
Driver Seat movement
121
Brake pedal/clutch pressure
123
Passenger sensor
125
Prediction algorithm
127
Driver ID confidence
129
Key-fob/mobile phone driver ID
131
Driver ID confirmation
133
Learning / Update Driver ID parameters / Prevent overwriting the settings
135
Driver ID parameters
137
KEY
A SLC Algorithm
B Drivers actions
C Key fob/phone identification
D Vehicle systems

FIG. 2

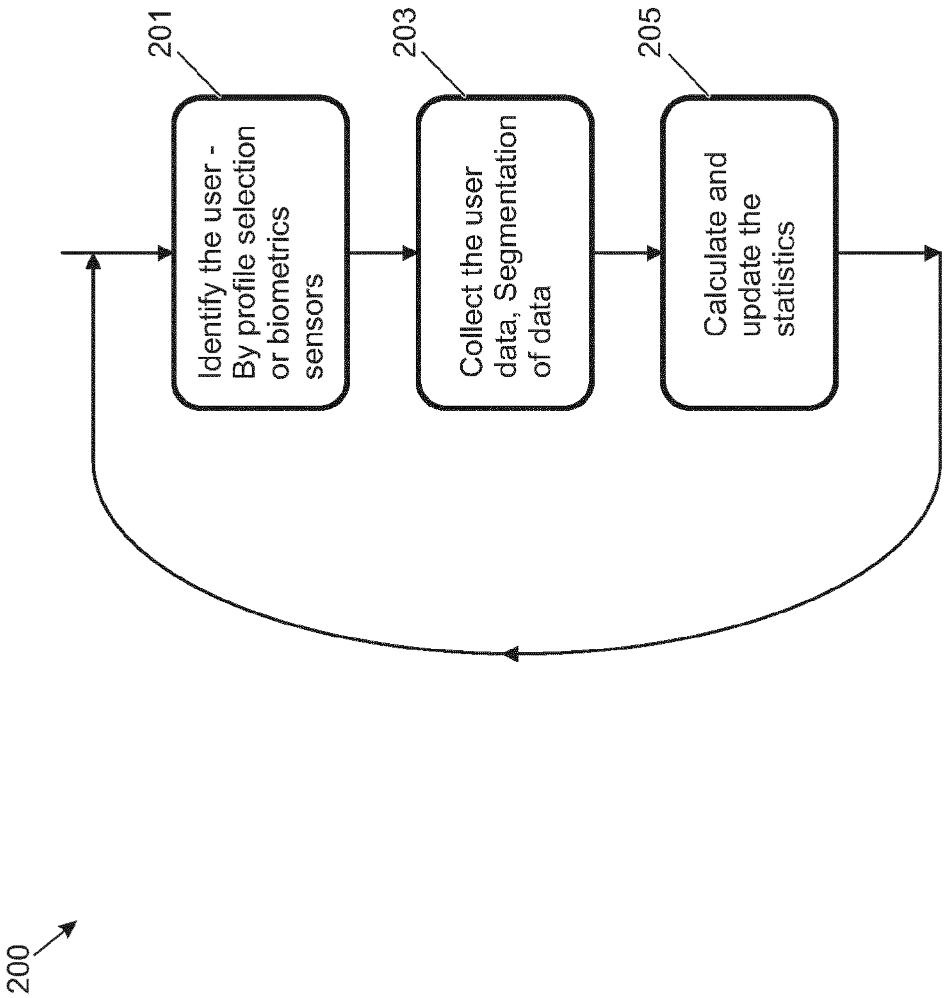
201
Identify the user - By profile selection or biometrics sensors
203
Collect the user data, Segmentation of data
205
Calculate and update the statistics
200

FIG. 3

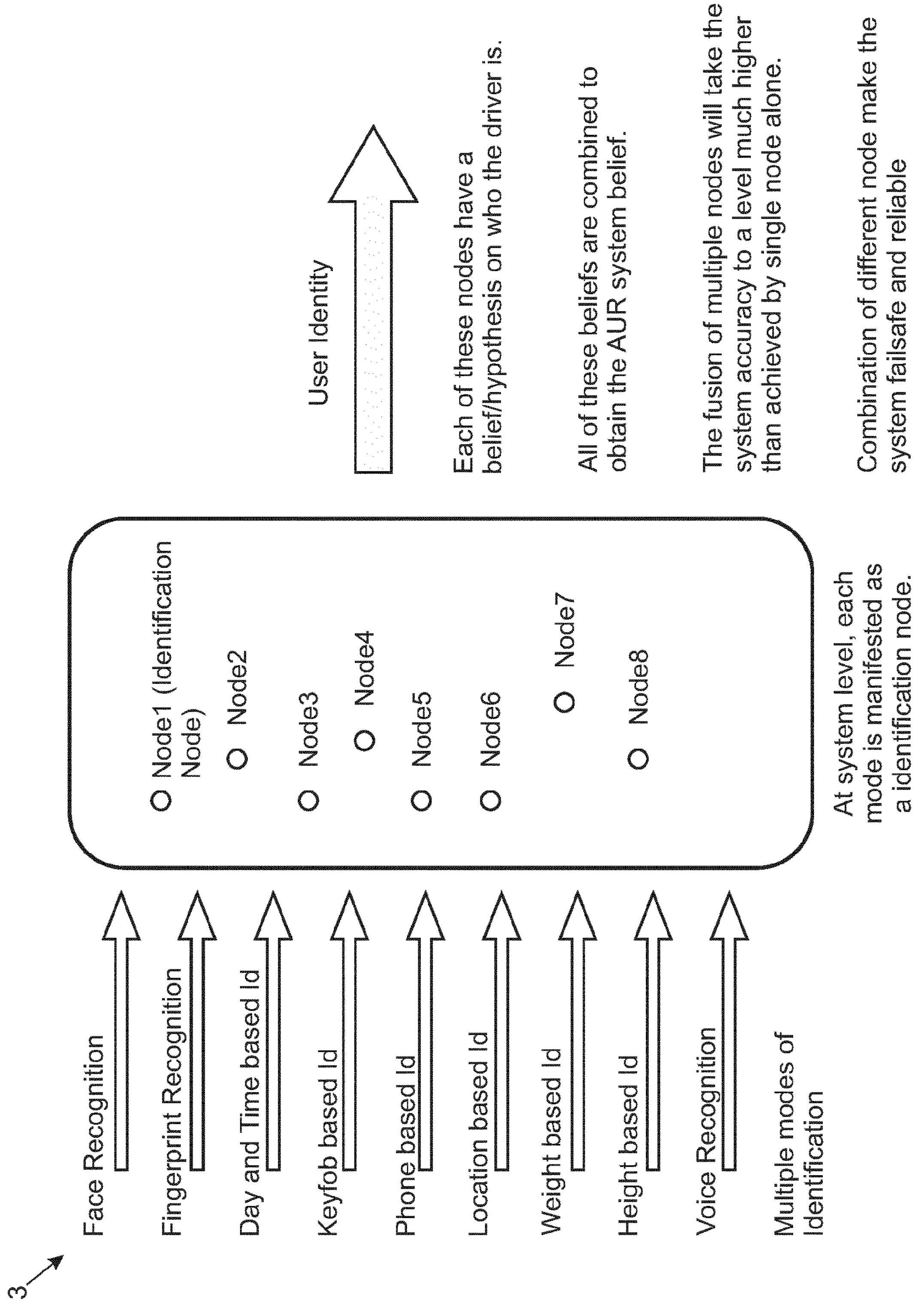
3
Face Recognition
Fingerprint Recognition
Day and Time based Id
Keyfob based Id
Phone based Id
Location based Id
Weight based Id
Height based Id
Voice Recognition
Multiple modes of Identification
Node1 (Identification Node)
Node2
Node3
Node4
Node5
Node6
Node7
Node8
At system level, each mode is manifested as a identification node.
User Identity
Each of these nodes have a belief/hypothesis on who the driver is.
All of these beliefs are combined to obtain the AUR system belief.
The fusion of multiple nodes will take the system accuracy to a level much higher than achieved by single node alone.
Combination of different node make the system failsafe and reliable

FIG. 4A

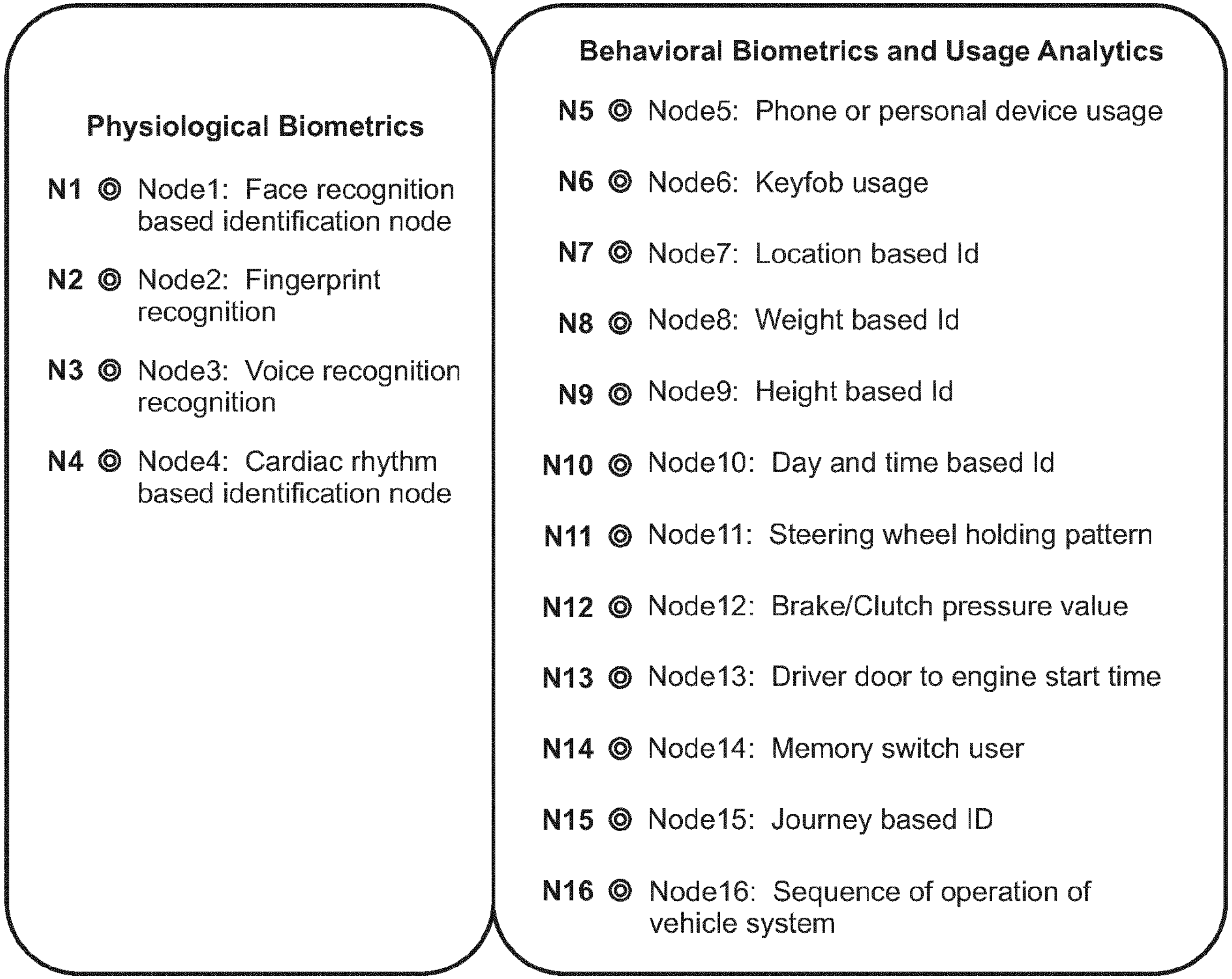
Physiological Biometrics
N1 ◎ Node1: Face recognition based identification node
N2 ◎ Node2: Fingerprint recognition
N3 ◎ Node3: Voice recognition recognition
N4 ◎ Node4: Cardiac rhythm based identification node
Behavioral Biometrics and Usage Analytics
N5 ◎ Node5: Phone or personal device usage
N6 ◎ Node6: Keyfob usage
N7 ◎ Node7: Location based Id
N8 ◎ Node8: Weight based Id
N9 ◎ Node9: Height based Id
N10 ◎ Node10: Day and time based Id
N11 ◎ Node11: Steering wheel holding pattern
N12 ◎ Node12: Brake/Clutch pressure value
N13 ◎ Node13: Driver door to engine start time
N14 ◎ Node14: Memory switch user
N15 ◎ Node15: Journey based ID
N16 ◎ Node16: Sequence of operation of vehicle system

FIG. 4B

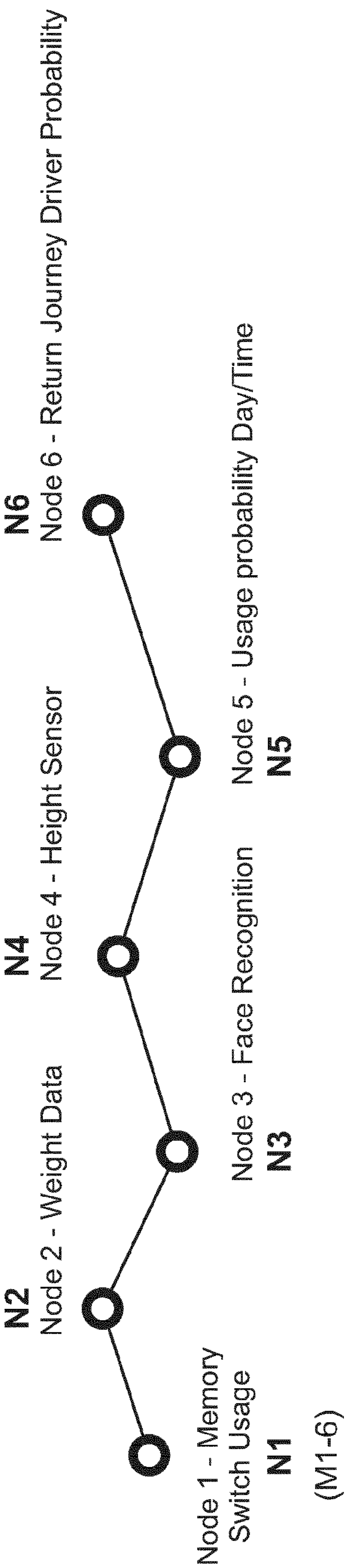
Node 1 - Memory Switch Usage
N1
(M1-6)
N2
Node 2 - Weight Data
Node 3 - Face Recognition
N3
N4
Node 4 - Height Sensor
Node 5 - Usage probability Day/Time
N5
N6
Node 6 - Return Journey Driver Probability

FIG. 4C

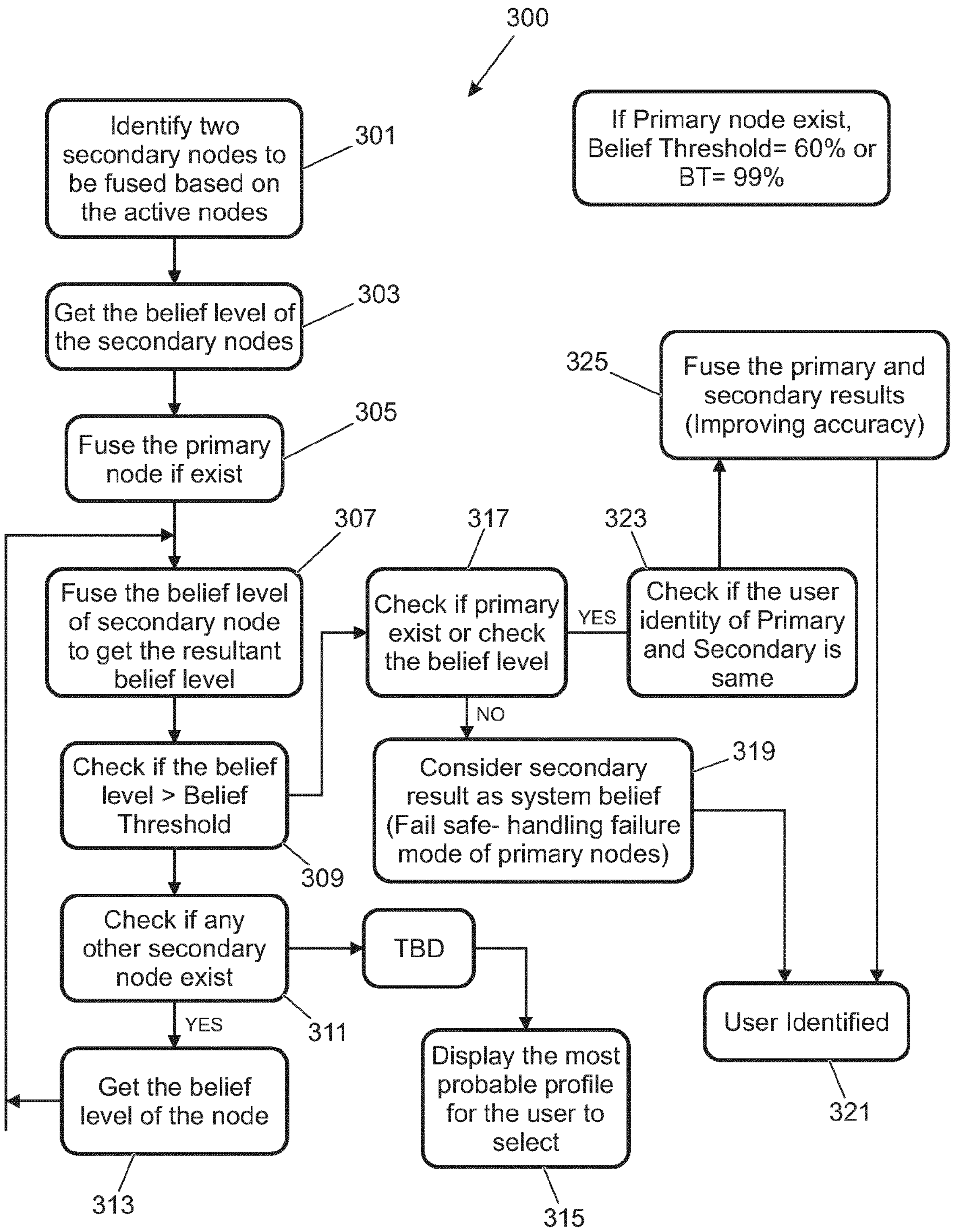
300
Identify two secondary nodes to be fused based on the active nodes
301
Get the belief level of the secondary nodes
303
Fuse the primary node if exist
305
Fuse the belief level of secondary node to get the resultant belief level
307
Check if the belief level > Belief Threshold
309
Check if any other secondary node exist
311
YES
Get the belief level of the node
313
TBD
Display the most probable profile for the user to select
315
Check if primary exist or check the belief level
317
NO
YES
Consider secondary result as system belief (Fail safe- handling failure mode of primary nodes)
319
Check if the user identity of Primary and Secondary is same
323
Fuse the primary and secondary results (Improving accuracy)
325
If Primary node exist, Belief Threshold= 60% or BT= 99%
User Identified
321

FIG. 5

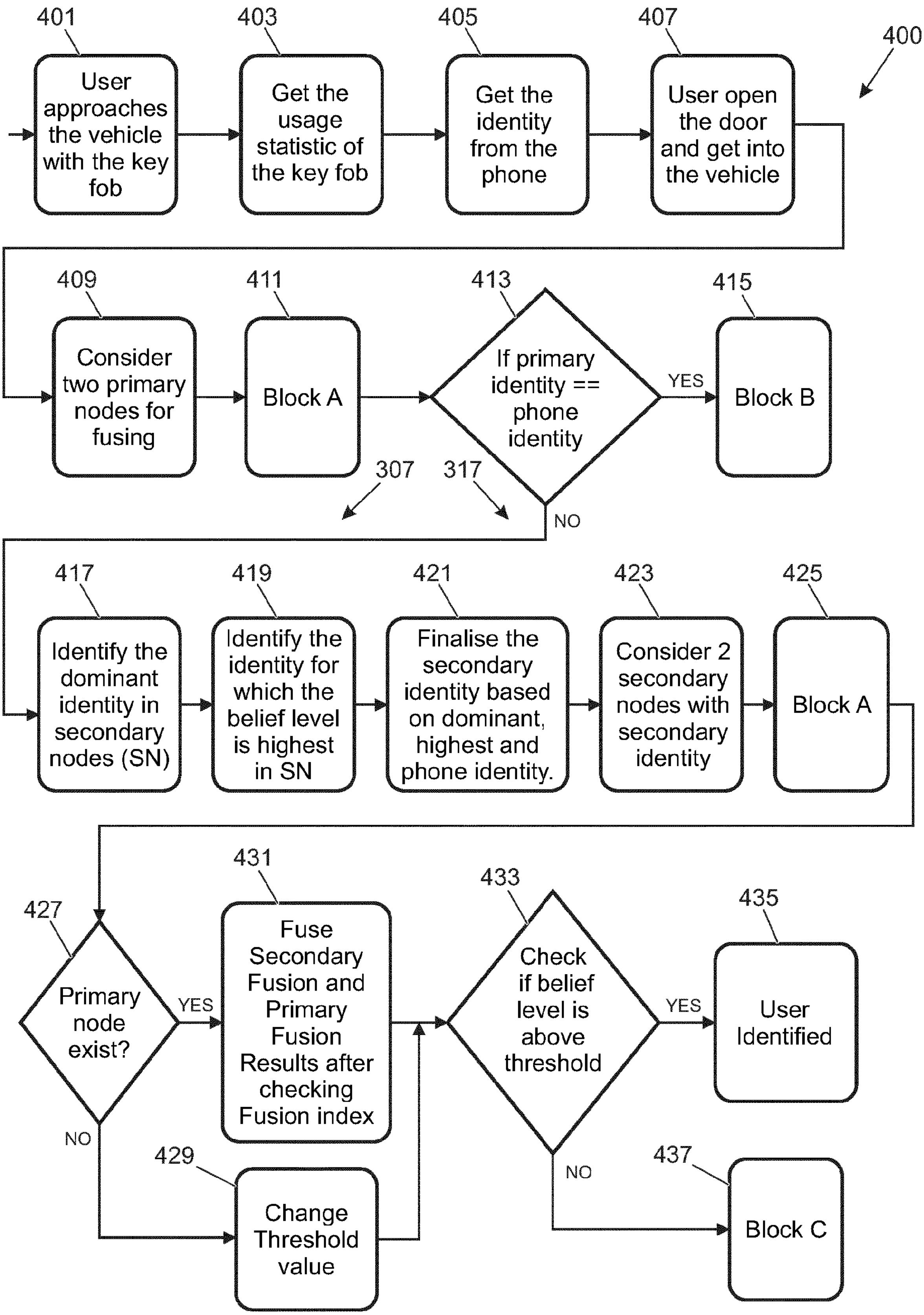
400
401
User approaches the vehicle with the key fob
403
Get the usage statistic of the key fob
405
Get the identity from the phone
407
User open the door and get into the vehicle
409
Consider two primary nodes for fusing
411
Block A
413
If primary identity == phone identity
YES
415
Block B
NO
307
317
417
Identify the dominant identity in secondary nodes (SN)
419
Identify the identity for which the belief level is highest in SN
421
Finalise the secondary identity based on dominant, highest and phone identity.
423
Consider 2 secondary nodes with secondary identity
425
Block A
427
Primary node exist?
YES
NO
431
Fuse Secondary Fusion and Primary Fusion Results after checking Fusion index
429
Change Threshold value
433
Check if belief level is above threshold
YES
NO
435
User Identified
437
Block C

FIG. 6

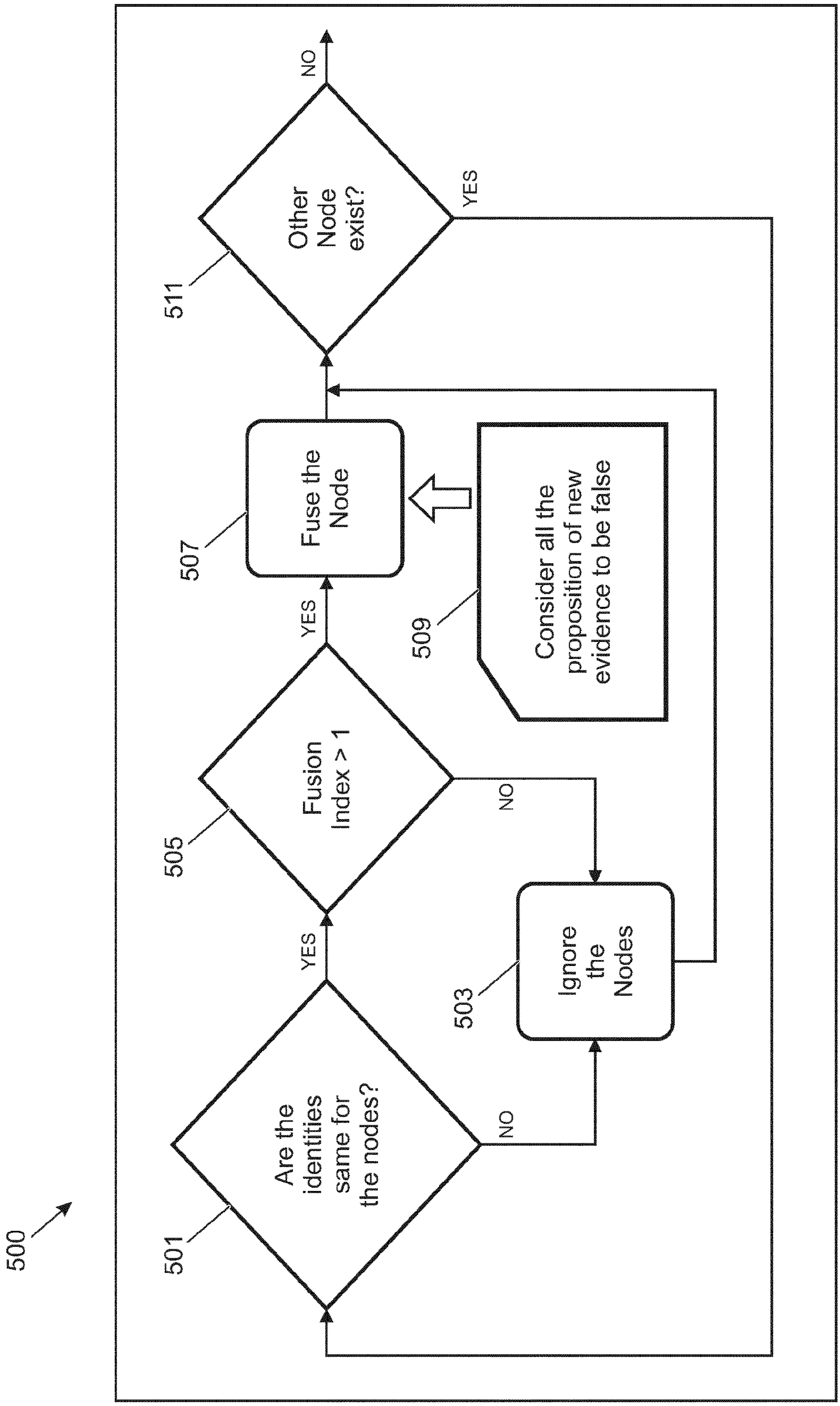
500
501
Are the identities same for the nodes?
NO
YES
503
Ignore the Nodes
505
Fusion Index > 1
NO
YES
507
Fuse the Node
509
Consider all the proposition of new evidence to be false
511
Other Node exist?
YES
NO

FIG. 7

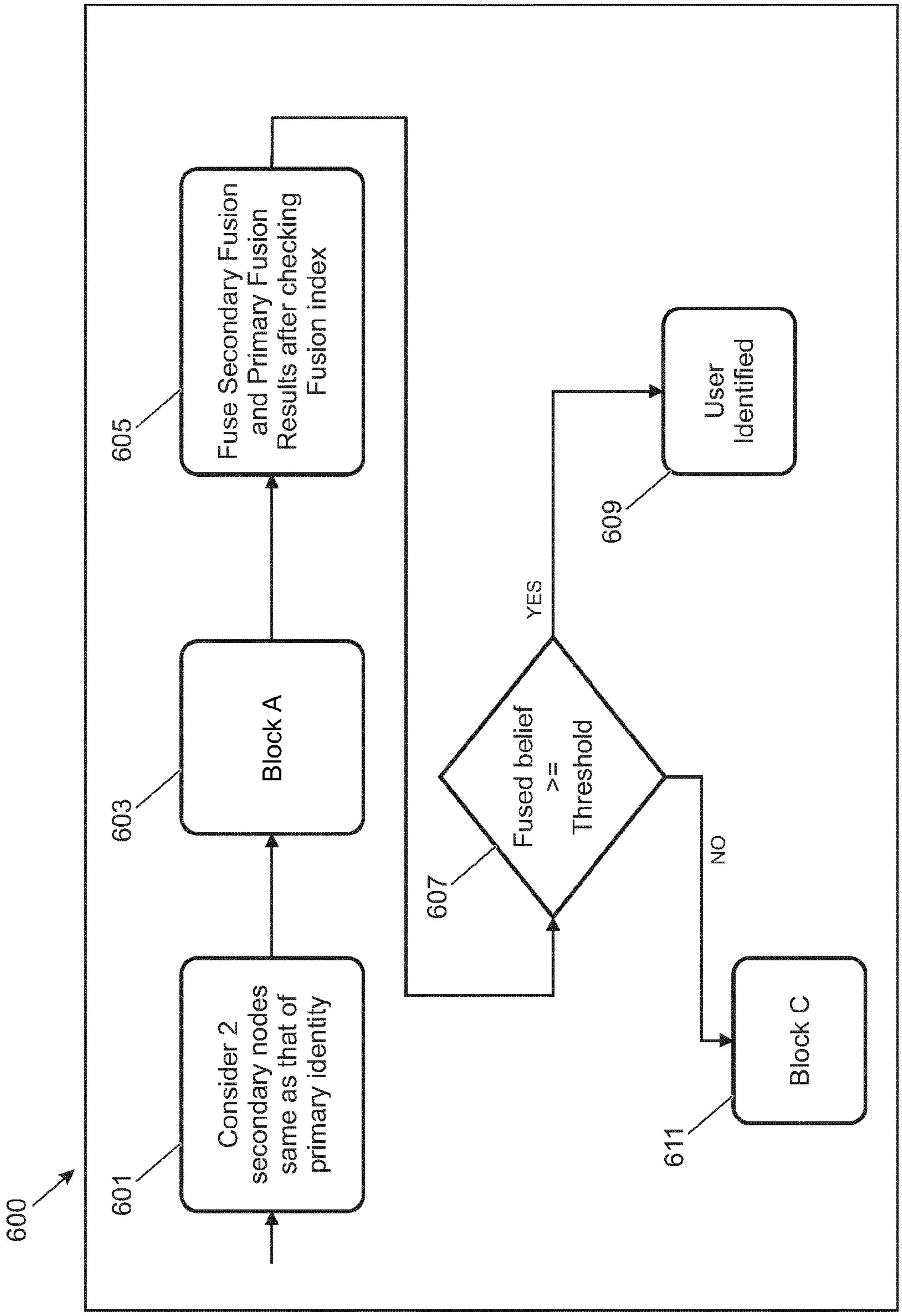
600
601
Consider 2 secondary nodes same as that of primary identity
603
Block A
605
Fuse Secondary Fusion and Primary Fusion Results after checking Fusion index
607
Fused belief >= Threshold
YES
NO
609
User Identified
611
Block C

FIG. 8

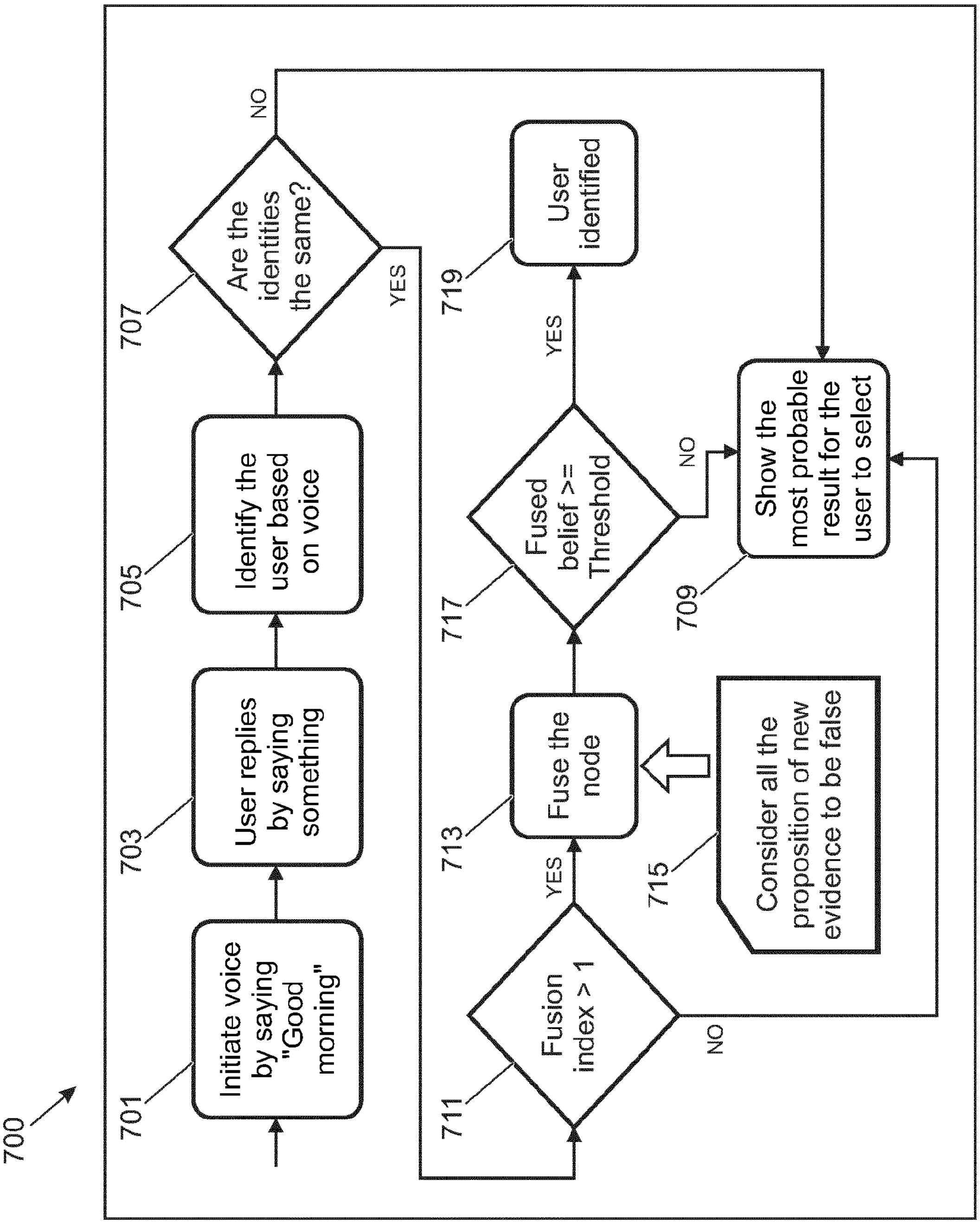
700
701
Initiate voice by saying "Good morning"
703
User replies by saying something
705
Identify the user based on voice
707
Are the identities the same?
YES
NO
711
Fusion index > 1
YES
NO
713
Fuse the node
715
Consider all the proposition of new evidence to be false
717
Fused belief >= Threshold
YES
NO
719
User identified
709
Show the most probable result for the user to select

FIG. 9

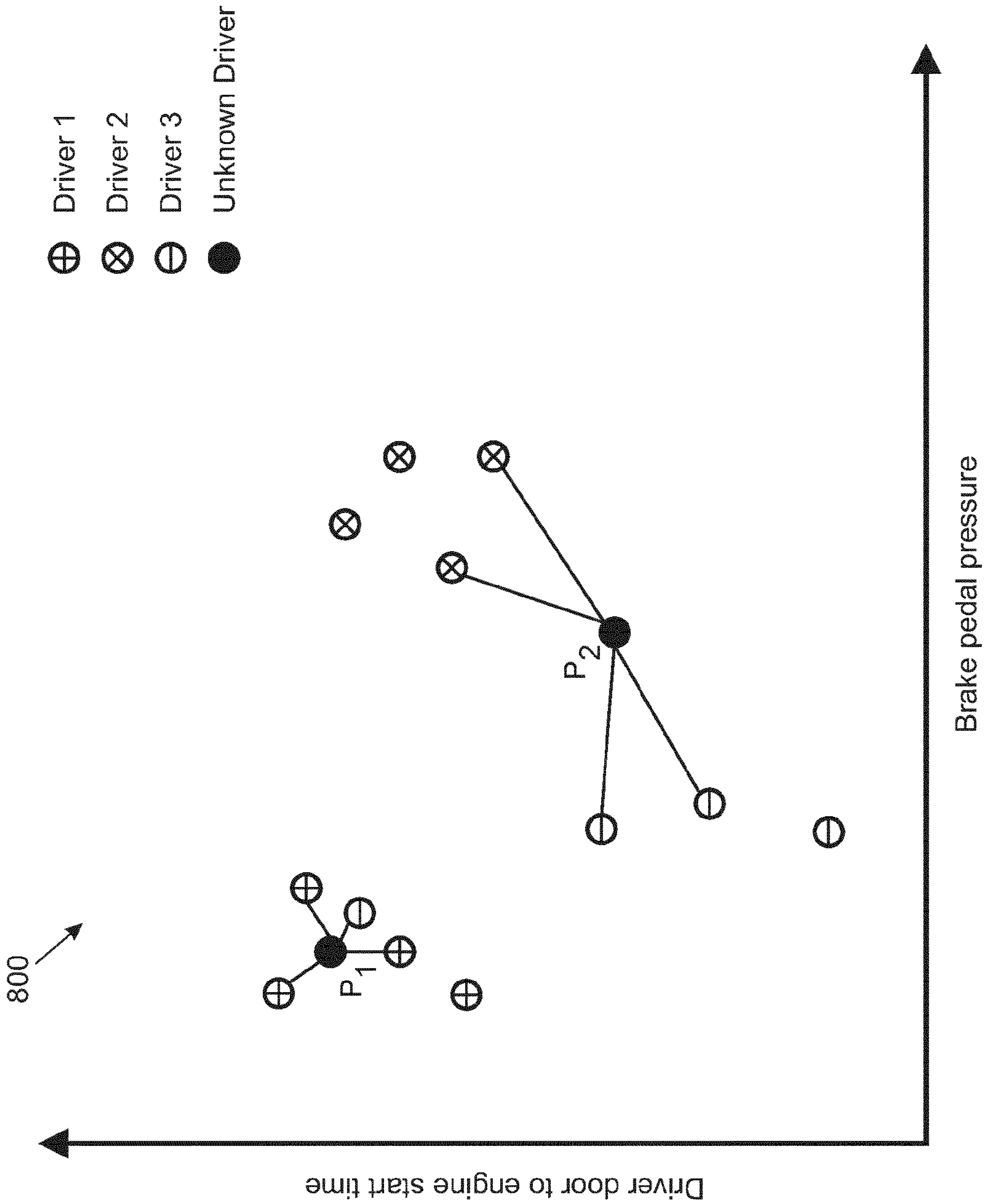
800
Driver 1
Driver 2
Driver 3
Unknown Driver
P1
P2
Brake pedal pressure
Driver door to engine start time

FIG. 10

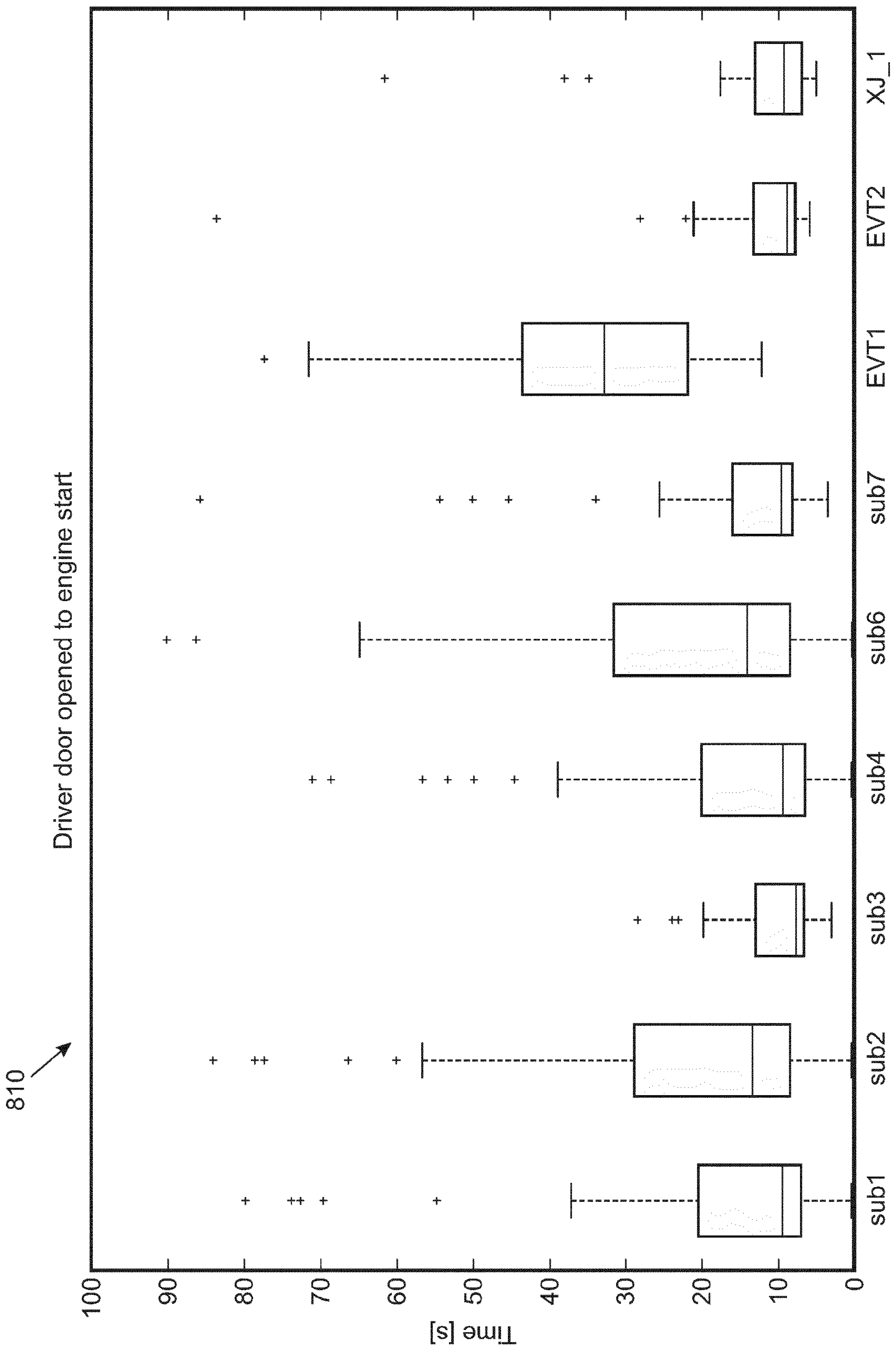
810
Driver door opened to engine start
Time [s]
0
10
20
30
40
50
60
70
80
90
100
sub1
sub2
sub3
sub4
sub6
sub7
EVT1
EVT2
XJ_1

FIG. 11

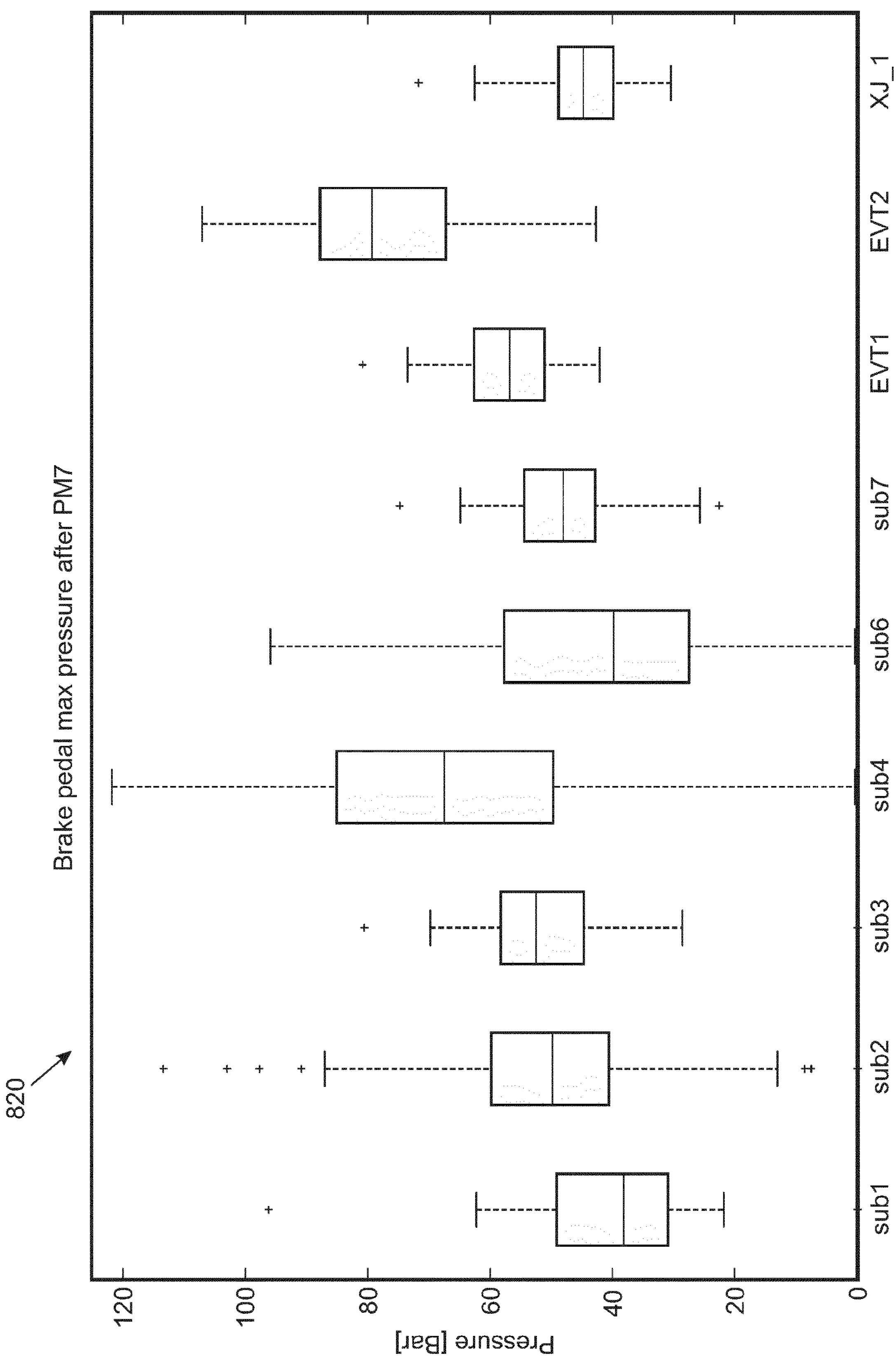
820
Brake pedal max pressure after PM7
Pressure [Bar]
0
20
40
60
80
100
120
sub1
sub2
sub3
sub4
sub6
sub7
EVT1
EVT2
XJ_1

FIG. 12

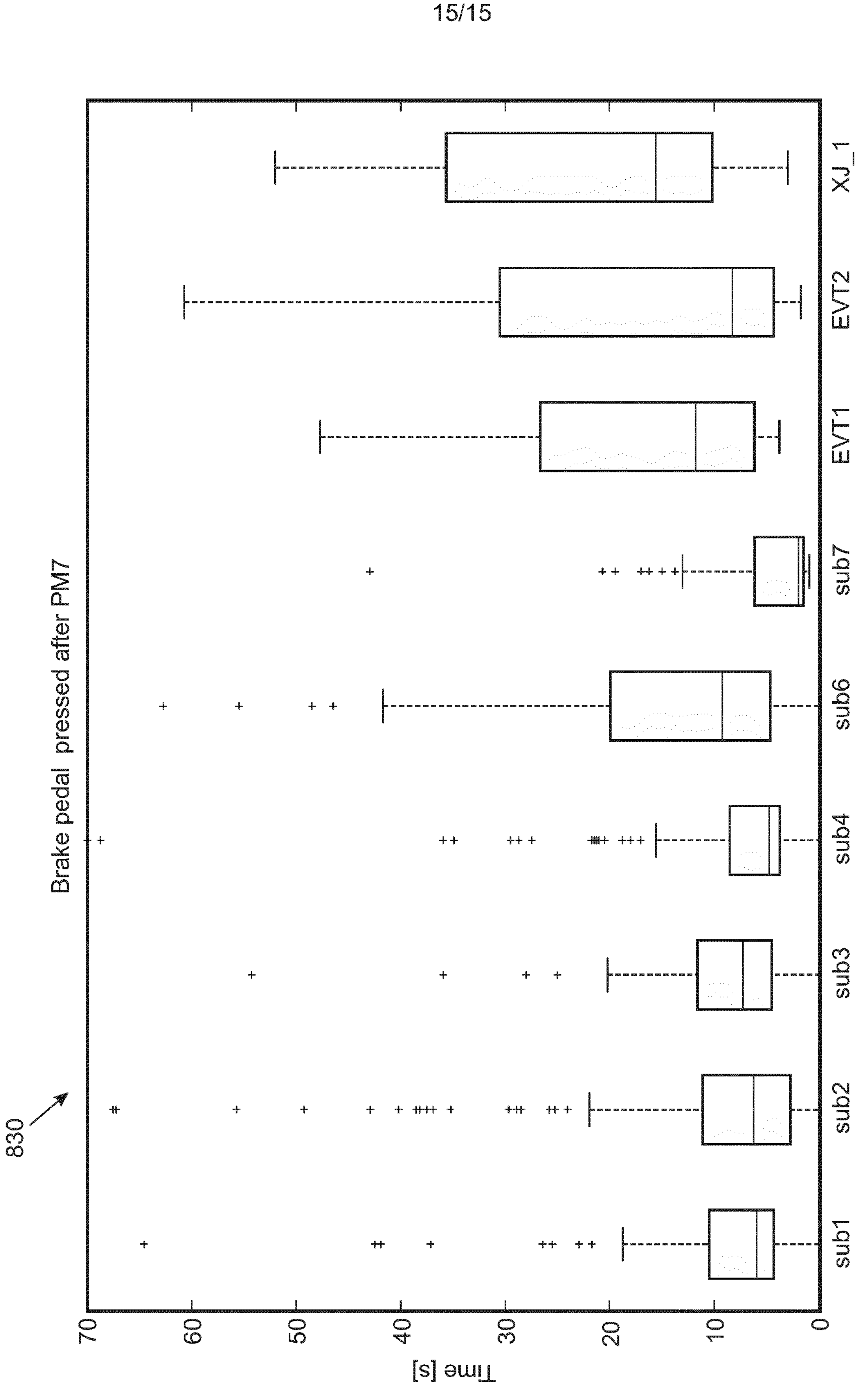
830
Brake pedal pressed after PM7
Time [s]
0
10
20
30
40
50
60
70
sub1
sub2
sub3
sub4
sub6
sub7
EVT1
EVT2
XJ_1

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/065460

A. CLASSIFICATION OF SUBJECT MATTER
INV. G07C9/00 G07C5/08
ADD.

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)
G07C

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/344856 A1 (SILVER ANDREW [US] ET AL) 26 December 2013 (2013-12-26) paragraph [0002] - paragraph [0005] paragraph [0027] - paragraph [0038] paragraph [0044] - paragraph [0059] figures 1-5 -----	1-39
X	WO 2013/101054 A1 (INTEL CORP [US]; GRAUMANN DAVID L [US]; HEALEY JENNIFER [US]; MONTESIN) 4 July 2013 (2013-07-04) page 3, line 4 - page 4, line 29 page 5, line 1 - page 7, line 23 page 10, line 9 - page 14, line 21 abstract; figures ----- -/--	1,2, 8-12, 15-20, 26-30, 33-39

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 October 2015	14/10/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Miltgen, Eric

1

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2007/158128 A1 (GRATZ ROSEMARIE M [US] ET AL) 12 July 2007 (2007-07-12) paragraph [0007] - paragraph [0016] paragraph [0024] - paragraph [0040] paragraph [0050] - paragraph [0051] figures -----	1-39

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2015/065460

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		US 2015140991 A1	21-05-2015
WO 2013101054 A1	04-07-2013	CN 104010914 A	27-08-2014
		EP 2797794 A1	05-11-2014
		JP 2015505284 A	19-02-2015
		US 2014195477 A1	10-07-2014
		WO 2013101054 A1	04-07-2013
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