(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 259 227 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
08.12.2010 Bulletin 2010/49

(51) Int Cl.:
G07B 15/00 *(2006.01)*

(21) Application number: **09468011.3**

(22) Date of filing: **04.12.2009**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR
Designated Extension States:
AL BA RS

(30) Priority: **01.06.2009 SI 200900154**

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(54) A method of determining use of geodesically allocable objects

(57) The present invention relates to a method for determining the use of geodesically allocable objects, said method being primarily intended for use by systems of automatic toll collection such as road tolls, parking fees and similar fees, related to the use of geodesically allocable objects. The present invention relates also to a device for carrying out said method.

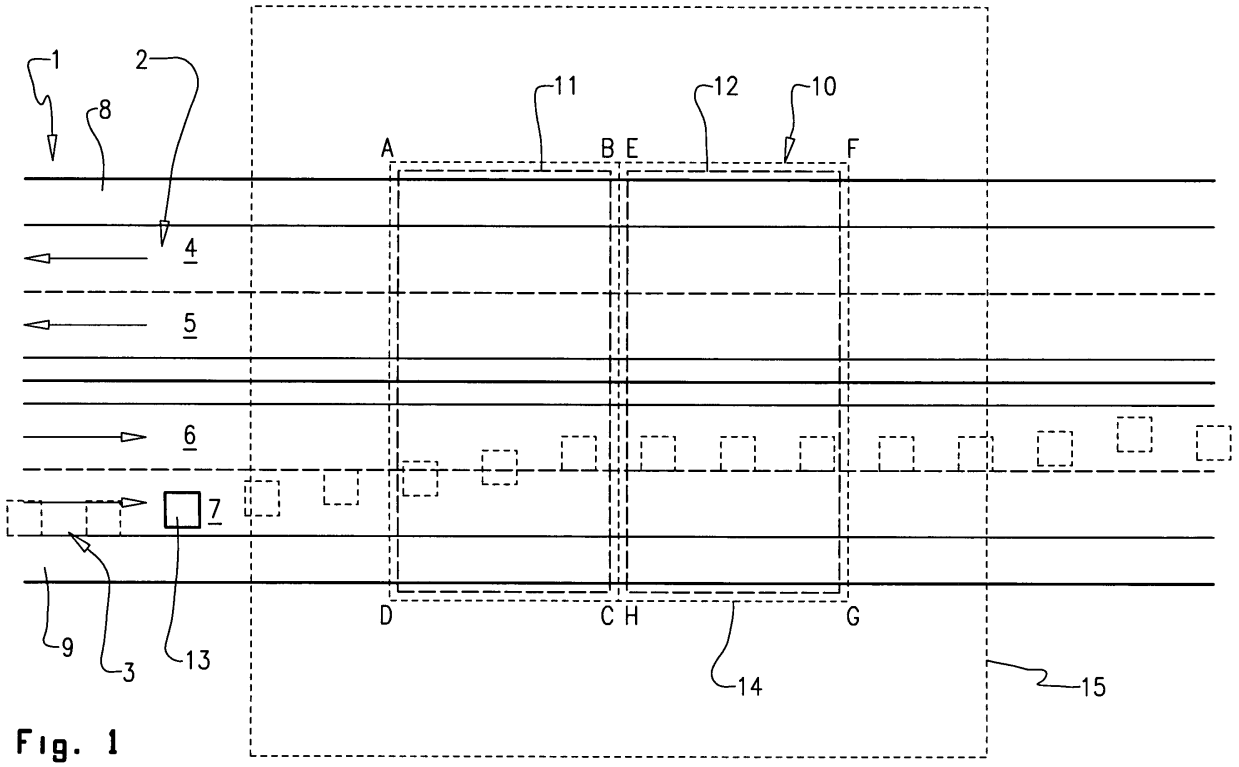

Fig. 1

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Description

[0001] The present invention relates to a method of determining use of geodesically allocable objects, said method being primarily intended for use by systems of automatic toll collection such as road tolls, parking fees and similar fees, related to the use of geodesically allocable objects.

[0002] The method of determining use of geodesically allocable objects is known, wherein use of the object is defined by taking into account a set of control points during identification, said control points represent the form of the entire area, for example, points, which represent axes of a motorway section. Said object is marked as used the moment a mobile unit is located in at least one of the control points of said entire area.

[0003] A drawback of said known solution is represented by the fact that geodesically allocable objects are dimensionally varied and described by a set of points, which in turn are not necessary for the definition of object itself. Thus, all the said increases requirement of storage medium, such as, for example, permanent or temporary storage of a mobile unit, following transmission and exchange of data, such as, for example, remote upload of a point map to a mobile unit, and requirements for processing of a set of data, such as, for example, a faster processor, greater use of power, higher cost of mobile unit, shorter autonomy. This means, with automatic road toll collection for example, that the determination of a single motorway section uses a set of a few 100 (hundred) or 1000 (thousand) points, which on a survey of the entire motorway network of a single country represents a set of data of a few million bytes.

[0004] Further drawback of said known solution is incapability of precise position allocation of the mobile unit. Namely, the position of the mobile unit may be determined in a number of manners, for example, by means of satellite navigation (for example, GPS, GLONASS), by means of a triangulation method, etc. Results of measured positions typically deviate from actual position of the mobile unit. Said deviations equal from a few metres to a few hundred metres. Known methods for determination of geodesically allocable objects compensate said inaccurately measured position by marking object as used the moment the mobile unit sufficiently approaches a control point from the entire list of points of the object. This means that the distance between the control point of said object and measured position of said mobile unit is in the order of magnitude of the measuring error, which typically occurs when determining position of the mobile unit.

[0005] Yet another drawback of known solution lies in an incorrect identification of used object which is the case when two or more objects are located close together (for example, a local road running parallel to the motorway). Close together in this case means that the distances among individual corridors are in the order of magnitude of the measuring error, which typically occurs when determining position of mobile unit. User of the first corridor, for which, for example, no record is kept on use of object, shall in this case be marked as using object in second corridor. With the system of automatic road toll collection this means that the user of the local road shall pay toll as if he had used the motorway.

[0006] It is the object of the present invention to create a method of determining use of geodesically allocable objects, which insures, with a minimal load of a mobile unit with data and a minimal transfer of said data between said mobile unit and a fixed control centre, a reliable determination of use of geodesically allocable objects, wherein the drawbacks of known solutions shall be remedied.

[0007] The object as set above is solved by a method according to the present invention, which ensures an efficient determination of use of geodesically allocable objects. Thus, the need for storage of large quantity of data in order to determine a position essentially decreases and, for example, in case of automatic road toll collection, the possibility of an erroneous identification of sections being travelled decreases.

[0008] It is generally known within the concerned field that the digital map is composed of individual points. Each point contains at least information of geographic latitude and geographic longitude (X and Y coordinates) and additional information, for example, type of an object to which the point belongs, name of a wider area. An object within the solution of the technical problem is represented as a closed polygon, which, as an identification area, includes part or whole of geodesically allocable objects (hereinafter GAO). Said polygon is composed in a manner that it connects boundary points of the identification area of GAO in sequence from the first to the last point, where it is connected with the first point and thus forms a closed whole.

[0009] GAOs primarily intended for toll collection, are of various forms and attributes. Motorway sections are typically pieceweise continuous, for bi-directional traffic, a few kilometres in length and without the possibility of exit prior to the final exit. In tunnels, precise determination of location is inaccurate even by means of a dead reckoning, thus identification is executed prior entry or following exit from the tunnel. Parking facilities are typically limited by their outlines and one or more entry or exit.

[0010] For each such GAO, one or more identification areas may be defined in the form of a polygon; the number of polygon points depends on the form and attributes of the object. The smallest number of polygon points is three, which represents a triangular identification area.

[0011] The invention will be more readily understood on reading the following description with reference to the accompanying drawings where

Fig. 1 shows a schematic view of a geodesically allocable object according to the invention, in a given example of a motorway section,

Fig. 2 shows schematically, a flow of a method ac-

cording to the invention,

Fig. 3 shows schematically, a flow of the second embodiment according to the invention.

[0012] By means of Fig. 1, an embodiment of a method according to the present invention is described, i.e. automatic toll payment. Thus, said automatic toll collection is implemented on a motorway 1, which in the given case includes two carriageways 2, 3, each with two traffic lanes 4, 5; 6, 7 and one emergency lane 8, 9. According to the present invention, it is provided for that at least one virtual toll station (hereinafter VTS) 10 is located between each entry and each exit in/from GAO, i.e. on/from motorway.

[0013] For the identification of the motorway section, two polygons 11, 12 are used, defined by at least 4 vertices A, B, C, D and B, F, G, H, said polygons 11, 12 being positioned typically at the beginning and the end of VTS 10. Said polygons 11, 12 cover the entire width of said motorway and run along the motorway track for a sufficient length. Said sufficient length means that at an assumed rate of capture of positions of the mobile unit 13, i.e. vehicle, (for example one capture per second) and vehicles travelling at highest speed (for example 300 km/h), at least one said position of the mobile unit 13 fits into said polygon A, B, C, D; E, F, G, H, said position of the mobile unit 13 defines with sufficient reliability belonging to GAO. Thus, Fig. 1 shows the mobile unit 13 in a given moment as a square drawn by a full line, while other possible positions are illustrated as squares drawn by a dashed line. Use of two polygons 11, 12 ensures definition of the travel direction also in case the traffic is rerouted to the opposite direction track 2 or 3, for example, due to works on a section of the motorway 1. In the case of a motorway architecture, where carriageways of one section never run along each other (for example carriageways run around a hill on different sides i.e. dual carriageway), polygons are duplicated for each individual carriageway. Typically, carriageways 2, 3 run in parallel; thus, it is possible to join the start and the end polygons 11, 12 into a single polygon 14 with six vertices A, BE, F, G, CH, D, where the two middle vertices BE, CH represent a boundary between the first polygon 11 and the second polygon 12. Said polygon 14 is located at an area, which, from the viewpoint of surrounding roads and objects, is least subjected to errors due to inaccuracy of defining position and is, in case of a road toll collection on a dual lane motorway, of typical dimensions 50 metres (width) and 300 metres (length). For greater reliability of operation, the length of said polygon 14 may be extended up to the maximum possible dimension, i.e. the length of the entire object.

[0014] It is also possible, according to the present invention, to use polygons with a greater number of vertices, which typically describe a GAO of arbitrary forms, for example, an entire country, city centres, local roads with a plurality of entries and exits, parking facilities and similar, without departing from the spirit and scope of the invention.

[0015] According to the first embodiment of the method for determining use of GAO according to the present invention, two polygons 11, 12 are provided, which are merged into said polygon 14, thus considerably reducing the quantity of map data (only approximately 75% of points is required in comparison with separate polygons 11, 12). The mobile unit, a vehicle for example, is equipped with all devices for the exchange and the processing of data, and due to limited small quantity of map data the mobile unit includes also suitable data collections about VTS. Here, a list S1 represents a temporary list, where the identified polygon 14 is recorded. At the beginning of determination of GAO, the list S1 is empty. A list S2 is intended for recording of visited areas of said polygon 14, i.e. areas 11, 12. At the start of the procedure the list S2 is empty.

[0016] At first step R1 of the method according to the invention, a point T1, which represents the current position of the mobile unit 13, is defined by means of a GPS device, for example. The second step R2 verifies that said point T1 is located either inside or on the boundary of said polygon 14 recorded in said data collection at VTS. If said point does not belong to said polygon 14, i.e. is located outside of said polygon 14, said lists S1 and S2 are deleted at step R3, and the position of the mobile unit 13 is obtained again.

[0017] If said point belongs to said polygon 14, the method according to the invention advances to a subsequent step R4, where it is verified if the identified polygon 14 is included on the list S1 of polygons already identified in previous steps. If polygon 14 is not on the list S1, it means that an identification of a new polygon starts; thus, the contents of S1 and S2 are deleted, and at a step R5 the new value of said polygon 14 is recorded to S1. Said method further continues with a step R6. If said polygon 14 already exists on the list S1, then these are other or further location readings within the same polygon 14, and the method continues with the step R6, where it is verified if the area 11, 12 of said polygon 14 is already on the list S2 of visited areas. If the area 11 has been previously recorded on the list S2, said point T1 belongs to the area already visited in previous steps; thus, the flow of the method is rerouted in order to obtain a new location according to the step R1, where also said point T1 in the second area 12 of the same polygon 14 is expected. If the area has not been included on the list S2, it is added in a following step R7.

[0018] If it is determined at a step R8 that all required areas 11, 12 of said polygon 14 have been identified and consequently the direction of travel has been defined, at step R9 the tolling of GAO is activated, such as toll charging or forwarding to toll charging centre. The method is subsequently returned to the initial step R1.

[0019] The second embodiment of the method according to the invention includes an additional mechanism at steps R10, R11, which prevents the omitting of partially identified GAO, occurring due to inaccuracy of the location unit (for example, GPS). For this purpose, a safety

frame 15, which is marked as an area of possible inaccuracy of said location unit, is provided for around said polygon 14.

[0020] In said second embodiment, the point T1, which represents the current position of the mobile unit 13, is determined at first at the step R1. Thereafter, at the step R2, it is verified if the point T1 is located within said polygon 14 or on the boundary of said polygon 14, stored in said data collection. If said point belongs to said polygon 14, the flow of the method continues with the step R4 and further steps as described above for the first embodiment of the method according to the invention.

[0021] If said point T1 misses said polygon 14, at least two causes are possible: the mobile unit 13 is actually located outside said polygon 14 (for example, it is just about to enter or just following exit from polygon) or an error occurred due to inaccuracy of the location set, which displaced the point T1 outside of said polygon 14. Thus, the step R10 first verifies if the point T1 is located within the safety frame 15. If the point T1 is near enough of said actual polygon 14, i.e. it is located within the safety frame 15 and outside of actual VTS, the lists S1 and S2 are not deleted since the determination of said polygon 14 may still be in process. Thus, in this case, the method returns to initial position at the step R1 in order to obtain a new point T1.

[0022] In case it is determined at the step R10 that the point T1 has fallen outside the area of the safety frame 15 and also outside said polygon 14, it is considered that the point T1 is actually a point, which does not belong to any of said polygons 14 or areas 11, 12. In this case, the lists S1 and S2 are deleted at the step R11 and the method for determination starts again with the step R1.

[0023] It is understood that the method according to the present invention is not limited to the described embodiments, since a number of different combinations is practically possible without departing from the spirit and scope of the invention.

Claims

1. A method for determining use of geodesically allocable objects, said method being primarily intended for use by systems of automatic toll collection such as road tolls, parking fees and similar fees, related to the use of geodesically allocable objects, comprising the steps of:

   a) step R1, with which the coordinates of mobile unit at a certain point T1 are obtained,
   b) step R2, during which it is verified if said point T1 is located within the identification area,
   c) step R3, which, in case said point T1 is located outside of the identification area, deletes lists S1 and S2 at the mobile unit and returns said method to the initial step R1,
   d) step R4, which, in case said point T1 is located within the identification area, verifies if said identification area has been already previously entered on said list S1,
   e) step R5, with which, in case an identification area is not on said list S1, an identification of a new identification area is triggered and contents of S1 and S2 deleted, wherein the new value of the identification area is stored to S1,
   f) step R6, with which it is verified if a certain area is already on the list of visited areas S2 and, in case the area has been previously classified on said list S2, said method is rerouted to obtain a new location as per step R1,
   g) step R7, with which an area is added, which was not previously entered on said list S2,
   h) step R8, with which it is determined if all required polygons have been identified; if not, said method returns to the initial step R1,
   i) step R9, with which the tolling of the identification area is activated, such as toll charging, forwarding to the toll charging centre, and return to the initial step R1.

2. A method for determining use of geodesically allocable objects, said method being primarily intended for use by systems of automatic toll collection such as road tolls, parking fees and similar fees, related to the use of geodesically allocable objects, comprising the steps of:

   a) step R1, with which the coordinates of the mobile unit at a certain point T1 are obtained,
   b) step R2, during which it is verified if said point T1 is located within the identification area,
   c) step R10, with which it is verified if said point T1 is located within the safety frame and, if said point T1 is near enough an identification area, lists S1 and S2 are not deleted, since the definition of said polygon 14 may still be under way; thus, said method is returned to the initial position at the step R1,
   d) step R11, which, in case it is determined in the step R10 that said point T1 has fallen outside the area of the safety frame and also outside of the identification area, deletes lists S1 and S2 and returns said method to the initial step R1.
   e) step R4, which, in case said point T1 is located within the identification area, verifies if the identification area has been previously entered on the list S1,
   f) step R5, with which, in case an identification area is not on the list S1, an identification of a new identification area is triggered, and contents of S1 and S2 deleted, wherein the new value of the identification area is written to S1,
   g) step R6, with which it is verified if a certain area is already on the list of visited areas S2 and, in case the area has been previously en-

tered on said list S2, said method is rerouted to obtain a new location as per step R1,
h) step R7, with which an area is added, which was not previously entered on said list S2,
i) step R8, with which it is determined if all required polygons have been identified; if not, said method returns to the initial step R1,
j) step R9, with which the assessment of the identification area is activated, such as toll charging, forwarding to the toll charging centre, and return to the initial step R1.

3. The device for determining use of geodesically allocable objects, said device being primarily intended for use with a method according to claims 1 or 2, ***characterised in that*** it comprises a closed polygon (11, 12; 14), which includes a part or whole geodesically allocable object (1) as an identification area (10), wherein said polygon (11, 12; 14) is composed in order to connect vertices of said identification area (10) in sequence from the first to the last point, where it joins with the first vertex and thus forms a closed whole.

4. The device according to claim 3, ***characterised in that*** for each geodesically allocable object (1) it is possible to define one or more identification areas (10) in the form of said polygon (11, 12; 14), wherein the number of vertices of said polygon (11, 12; 14) depends on the form and attributes of the geodesically allocable object (1).

5. The device according to claims 3 or 4, ***characterised in that*** the number of vertices of said polygon (11, 12; 14) is at least three.

6. The device according to any claim 3 to 5, ***characterised in that*** between each entry into the geodesically allocable object and each exit from the geodesically allocable object there is arranged at least one identification area (10).

7. The device according to any claim 3 to 6, ***characterised in that*** the number of vertices of said polygon (11, 12; 14) is such that it is possible to describe with said vertices an arbitrary geodesically allocable object, for example an entire country, city centre, local road, parking area and similar.

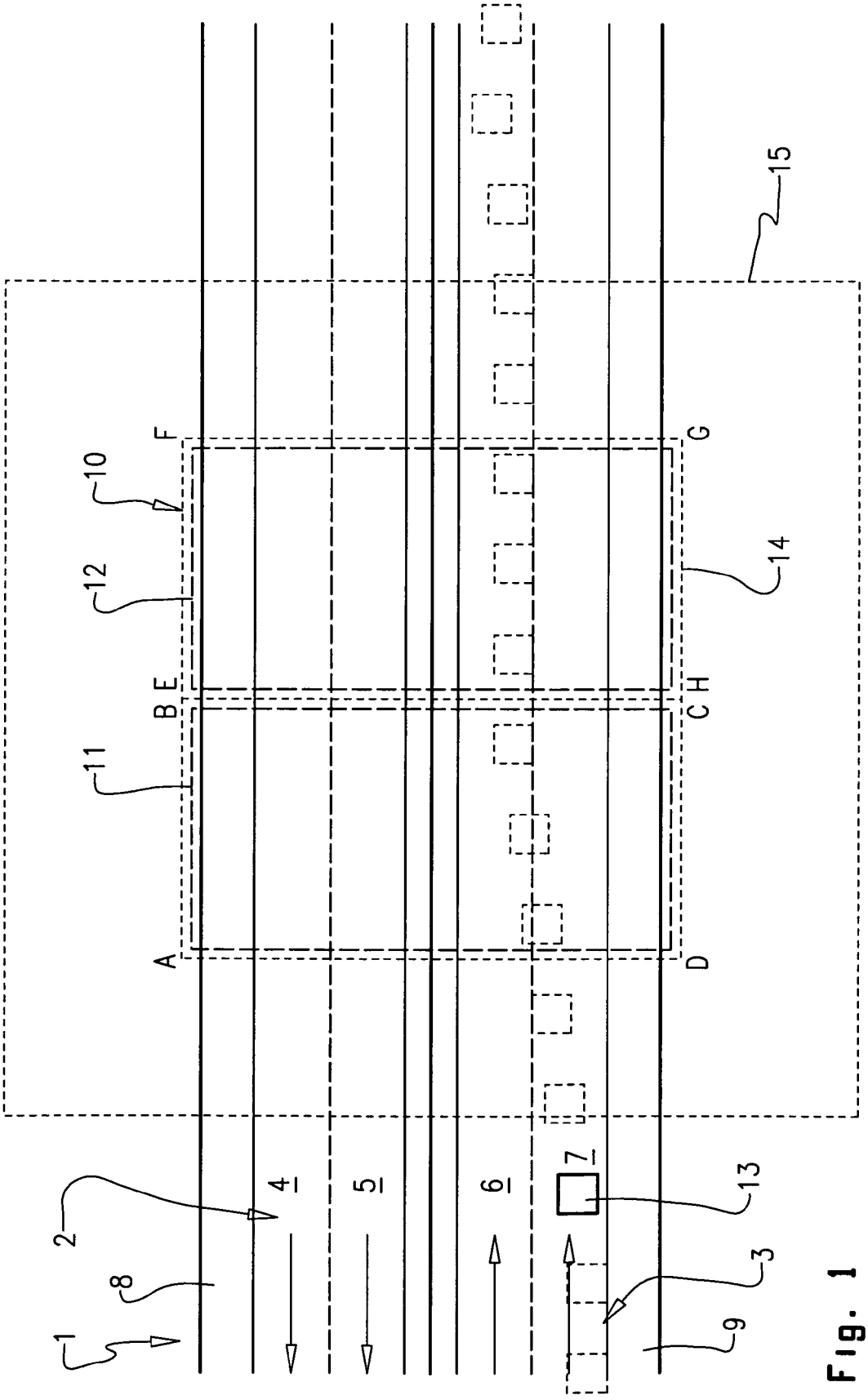

Fig. 1

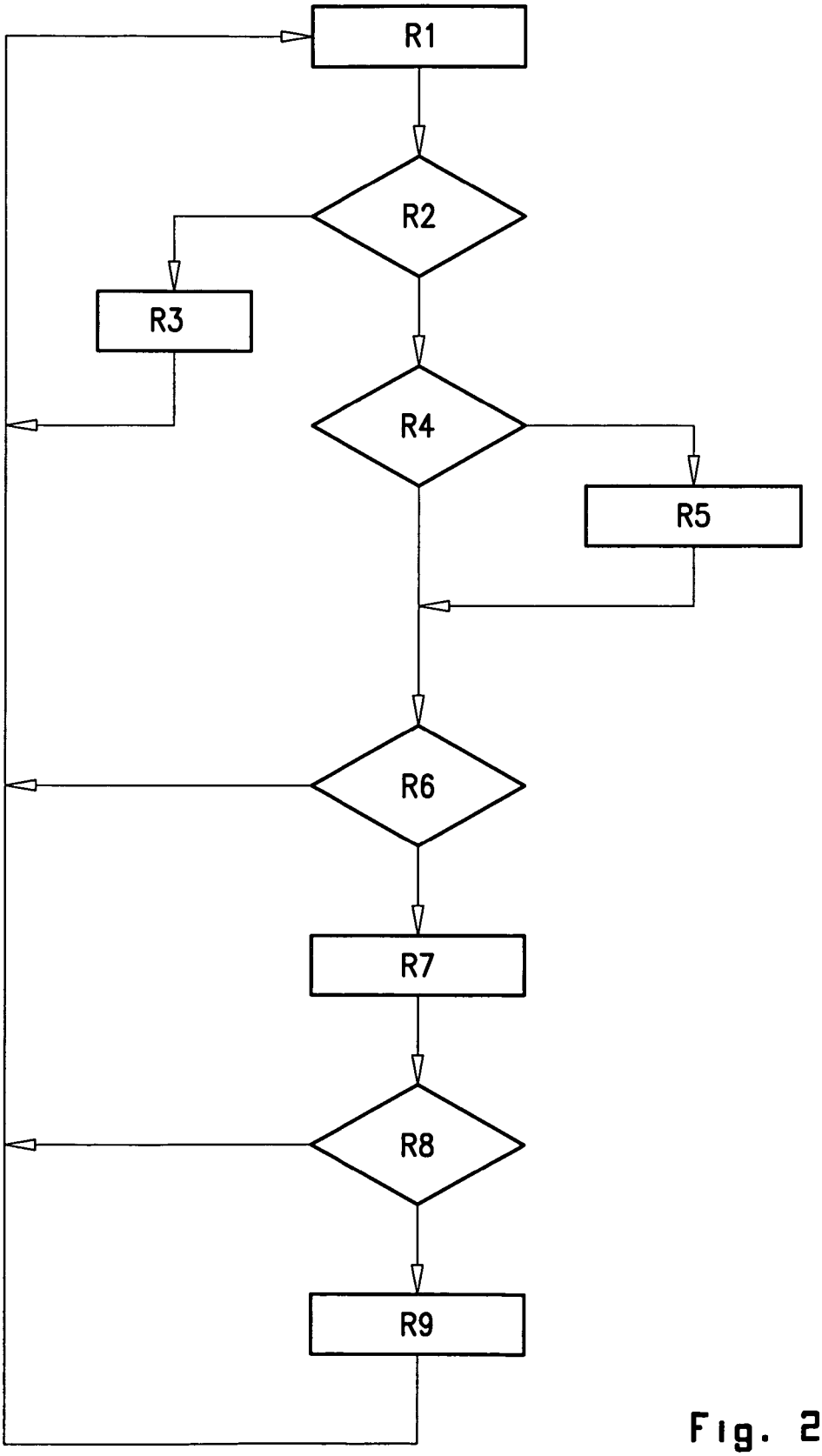

Fig. 2

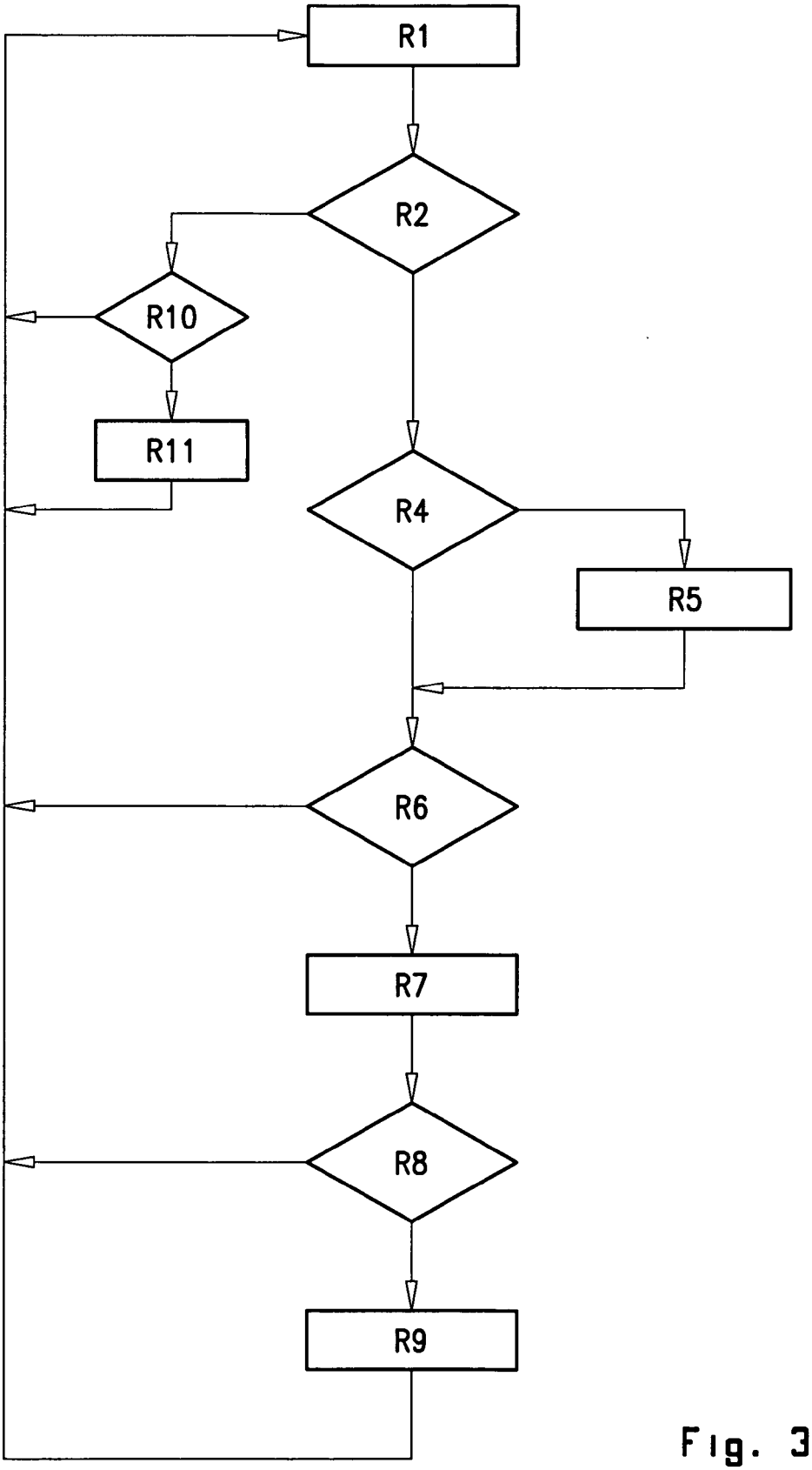

Fig. 3