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

(11) **EP 2 259 227 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
14.03.2018 Bulletin 2018/11

(51) Int Cl.:
G07B 15/00 *(2011.01)*

(21) Application number: **09468011.3**

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

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

Verfahren zur Bestimmung der Verwendung von geodätisch zuweisbaren Objekten

Procédé de détermination de l'utilisation d'objets attribués géodésiquement

(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

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

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

(73) Proprietor: **RC IRC Celje, d.o.o.**
3000 Celje (SI)

(72) Inventors:
- **Vezocnik, Ivan**
  3303 Gomilsko (SI)
- **Bester, Janez**
  4201 Zgornja Besnica (SI)
- **Stern, Andrej**
  2391 Prevalje (SI)

(74) Representative: **Ivancic, Bojan**
Inventio d.o.o.
Dolenjska cesta 11
P.O. Box 2410
1001 Ljubljana (SI)

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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] Determining use of geodesically allocable objects is generally 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] Similar methods are disclosed in several published documents such as WO 03/098556 A1, EP 1 909 231 A1, US 2004/153401 A1, US 4 982 332 A, US 2005/216187 A1, for instance. However, all known solutions exhibit certain features which, in general, may be summarized as impractical and/or complex. Said known solutions either comprise large maps, work on huge amount of determination points, which in turn results in rather large storage and processing facilities within the mobile unit, such as within the vehicle.

[0004] 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.

[0005] The object as set above is solved by a method according to independent claim 1, 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.

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.

GAOs primarily intended for toll collection, are of various forms and attributes. Motorway sections are typically piecewise 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.

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.

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 according to the invention,

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

[0006] 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.

[0007] 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.

[0008] 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. 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.

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.

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.

[0009] 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.

[0010] 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.

[0011] 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.

[0012] 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.

[0013] 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.

Claims

1. Method for determining the use of a geodesically allocable object by a mobile unit (13), the geodesically allocable object comprising at least one identification

area (10, 14) and at least one area (11,12), the at least one area being positioned at the at least one identification area and being in the form of a polygon connecting the vertices of the at least one area, the mobile unit (13) being adapted to exchange and process data and to store a data collection about the at least one identification area and recording the boundaries of the at least one identification area, the mobile unit (13) further being adapted to store a temporary list S1 for recording an identified identification area (14) and a list S2 for recording a visited area (11, 12) of the identified identification area, the method comprising the consecutive steps of

a) obtaining the coordinates of the mobile unit (13) at a point T1 (R1),
b) verifying whether point T1 is located either inside or on the boundary of the identification area (14), using the boundaries of the identification area (14) recorded in the data collection stored in the mobile unit (R2),
c) in case point T1 is outside the identification area (14), erasing the content of lists S1 and S2 and returning to step a) (R3),
d) in case point T1 is inside or on the boundary of the identification area (14), verifying whether the identification area (14) is already entered in list S1 (R4),
e) in case the identification area (14) is in list S1, jumping to step g),
f) in case the identification area (14) is not in list S1, first erasing the content of lists S1 and S2 and then entering the identification area (14) as an identified identification area in list S1 (R5),
g) verifying whether the current area (11,12) of the mobile unit (13) is already entered in list S2 (R6),
h) in case the area (11,12) is in list S2, returning to step a),
i) in case the area (11,12) is not in list S2, entering the area as a visited area in list S2 (R7),
j) determining whether all areas (11,12) of the identification area (14) have been visited (R8),
k) in case that not all areas (11,12) of the identification area (14) have been visited, returning to step a),
l) in case all areas (11,12) of the identification area (14) have been visited, activating tolling for the identification area and returning to step a) (R9).

2. Device for determining the use of geodesically allocable objects, said device comprising means for carrying out the method of claim 1, ***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).

3. The device according to claim 2, ***characterised in that*** the number of vertices of said polygon (11, 12; 14) is at least three.

4. The device according to claim 2 or 3, ***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).

5. The device according to any claim 2 to 4, ***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.

Patentansprüche

1. Verfahren zur Bestimmung der Verwendung eines geodätisch zuordenbaren Objekts durch eine mobile Einheit (13), wobei das geodätisch zuordenbare Objekt wenigstens einen Identifizierungsbereich (10, 14) und wenigstens einen Bereich (11,12) umfasst, wobei der wenigstens eine Bereich an dem wenigstens einen Identifizierungsbereich positioniert ist und die Form eines Polygons hat, das die Eckpunkte des wenigstens einen Bereichs verbindet, wobei die mobile Einheit (13) angepasst ist, um Daten auszutauschen und zu verarbeiten und eine Datensammlung über den wenigstens einen Identifizierungsbereich zu speichern und die Grenzen des wenigstens einen Identifizierungsbereichs zu erfassen, wobei die mobile Einheit (13) ferner angepasst ist, um eine temporäre Liste S1 zur Aufzeichnung eines erkannten Identifizierungsbereichs (14) und eine Liste S2 zur Aufzeichnung eines besuchten Bereichs (11, 12) des erkannten Identifizierungsbereichs zu speichern, wobei das Verfahren als aufeinanderfolgende Schritte umfasst

a) Erhalten der Koordinaten der mobilen Einheit (13) an einem Punkt T1 (R1),
b) Prüfen, ob sich der Punkt T1 entweder innerhalb oder auf der Grenze des Identifizierungsbereichs (14) befindet, wobei die Grenzen des Identifizierungsbereichs (14), die in der Datensammlung erfasst sind, welche in der mobilen Einheit (R2) gespeichert ist, verwendet werden,
c) wobei für den Fall, dass Punkt T1 außerhalb des Identifizierungsbereichs (14) liegt, der Inhalt der Listen S1 und S2 gelöscht wird und zu Schritt a) zurückgekehrt wird (R3),
d) wobei für den Fall, dass Punkt T1 innerhalb

oder auf der Grenze des Identifizierungsbereichs (14) liegt, geprüft wird, ob der Identifizierungsbereich (14) bereits in der Liste S1 eingetragen ist (R4),
e) wobei für den Fall, dass der Identifizierungsbereich (14) in der Liste S1 ist, zu dem Schritt g) gesprungen wird,
f) wobei für den Fall, dass der Identifizierungsbereich (14) nicht in der Liste S1 ist, zuerst der Inhalt der Listen S1 und S2 gelöscht wird und danach der Identifizierungsbereich (14) als ein erkannter Identifizierungsbereich in die Liste S1 eingetragen wird (R5),
g) Prüfen, ob der gegenwärtige Bereich (11,12) der mobilen Einheit (13) bereits in der Liste S2 eingetragen ist (R6),
h) wobei für den Fall, dass der Bereich (11,12) in der Liste S2 ist, zu dem Schritt a) zurückgekehrt wird,
i) wobei für den Fall, dass der Bereich (11,12) nicht in der Liste S2 ist, der Bereich als ein besuchter Bereich in die Liste S2 eingetragen wird (R7),
j) Ermitteln, ob alle Bereiche (11,12) des Identifizierungsbereichs (14) besucht wurden (R8),
k) wobei für den Fall, dass nicht alle Bereiche (11,12) des Identifizierungsbereichs (14) besucht wurden, zu dem Schritt a) zurückgekehrt wird,
l) wobei für den Fall, dass alle Bereiche (11,12) des Identifizierungsbereichs (14) besucht wurden, die Abgabe für den Identifizierungsbereich aktiviert wird und zu dem Schritt a) zurückgekehrt wird (R9).

2. Vorrichtung zur Bestimmung der Verwendung von geodätisch zuordenbaren Objekten, wobei die Vorrichtung Mittel umfasst, um das Verfahren nach Anspruch 1 auszuführen, ***dadurch gekennzeichnet, dass*** es für jedes geodätisch zuordenbare Objekt (1) möglich ist, einen oder mehrere Identifizierungsbereiche (10) in der Form des Polygons (11, 12, 14) zu definieren, wobei die Anzahl der Eckpunkte des Polygons (11, 12, 14) von der Form und den Eigenschaften des geodätisch zuordenbaren Objekts (1) abhängig ist.

3. Vorrichtung nach Anspruch 2, ***dadurch gekennzeichnet, dass*** die Anzahl der Eckpunkte des Polygons (11, 12, 14) wenigstens drei beträgt.

4. Vorrichtung nach Anspruch 2 oder 3, ***dadurch gekennzeichnet, dass*** zwischen jedem Zugang in das geodätisch zuordenbare Objekt und jedem Ausgang aus dem geodätisch zuordenbaren Objekt wenigstens ein Identifizierungsbereich (10) angeordnet ist.

5. Vorrichtung nach einem der Ansprüche 2 bis 4, ***dadurch gekennzeichnet, dass*** die Anzahl der Eckpunkte des Polygons (11, 12, 14) derart ist, dass es möglich ist, mit diesen Eckpunkten ein beliebiges geodätisch zuordenbares Objekt zu beschreiben, beispielsweise ein ganzes Land, ein Stadtzentrum, eine örtliche Straße, einen Parkbereich und dergleichen.

Revendications

1. Procédé pour déterminer l'utilisation d'un objet attribuable géodésiquement par une unité mobile (13), l'objet attribuable géodésiquement comprenant au moins une zone d'identification (10, 14) et au moins une zone (11, 12), l'au moins une zone étant positionnée au niveau de l'au moins une zone d'identification et se présentant sous la forme d'un polygone reliant les sommets de l'au moins une zone, l'unité mobile (13) étant apte à échanger et traiter des données et à stocker une collection de données concernant l'au moins une zone d'identification et enregistrant les limites de l'au moins une zone d'identification, l'unité mobile (13) étant en outre apte à stocker une liste temporaire S1 pour enregistrer une zone d'identification identifiée (14) et une liste S2 pour enregistrer une zone visitée (11, 12) de la zone d'identification identifiée, le procédé comprenant les étapes consécutives :

a) obtenir les coordonnées de l'unité mobile (13) à un point T1 (R1),
b) vérifier si le point T1 est situé soit à l'intérieur soit sur la limite de la zone d'identification (14), en utilisant les limites de la zone d'identification (14) enregistrées dans la collection de données stockée dans l'unité mobile (R2),
c) dans le cas où le point T1 se trouve hors de la zone d'identification (14), effacer le contenu des listes S1 et S2 et retourner à l'étape a) (R3),
d) dans le cas où le point T1 se trouve à l'intérieur ou sur la limite de la zone d'identification (14), vérifier si la zone d'identification (14) a déjà été entrée dans la liste S1 (R4),
e) dans le cas où la zone d'identification (14) est dans la liste S1, passer à l'étape g),
f) dans le cas où la zone d'identification (14) n'est pas dans la liste S1, tout d'abord effacer le contenu des listes S1 et S2 puis entrer la zone d'identification (14) en tant que zone d'identification identifiée dans la liste S1 (R5),
g) vérifier si la zone actuelle (11, 12) de l'unité mobile (13) a déjà été entrée dans la liste S2 (R6),
h) dans le cas où la zone (11, 12) est dans la liste S2, retourner à l'étape a),
i) dans le cas où la zone (11, 12) n'est pas dans la liste S2, entrer la zone en tant que zone visitée

dans la liste S2 (R7),
j) déterminer si toutes les zones (11, 12) de la zone d'identification (14) ont été visitées (R8),
k) dans le cas où les zones (11, 12) de la zone d'identification (14) n'ont pas toutes été visitées, retourner à l'étape a),
l) dans le cas où toutes les zones (11, 12) de la zone d'identification (14) ont été visitées, activer le péage pour la zone d'identification et retourner à l'étape a) (R9).

2. Dispositif pour déterminer l'utilisation d'objets attribuables géodésiquement, ledit dispositif comprenant des moyens pour mettre en oeuvre le procédé selon la revendication 1, **caractérisé par le fait que**, pour chaque objet attribuable géodésiquement (1), il est possible de définir une ou plusieurs zones d'identification (10) sous la forme dudit polygone (11, 12 ; 14), le nombre de sommets dudit polygone (11, 12 ; 14) dépendant de la forme et des attributs de l'objet attribuable géodésiquement (1).

3. Dispositif selon la revendication 2, **caractérisé par le fait que** le nombre de sommets dudit polygone (11, 12 ; 14) est au moins trois.

4. Dispositif selon l'une quelconque des revendications 2 ou 3, **caractérisé par le fait qu'**entre chaque entrée dans l'objet attribuable géodésiquement et chaque sortie de l'objet attribuable géodésiquement, il y a au moins une zone d'identification (10).

5. Dispositif selon l'une quelconque des revendications 2 à 4, **caractérisé par le fait que** le nombre de sommets dudit polygone (11, 12 ; 14) est tel qu'il est possible de décrire, avec lesdits sommets, un objet attribuable géodésiquement arbitraire, par exemple un pays entier, un centre-ville, une route locale, une zone de stationnement et analogue.

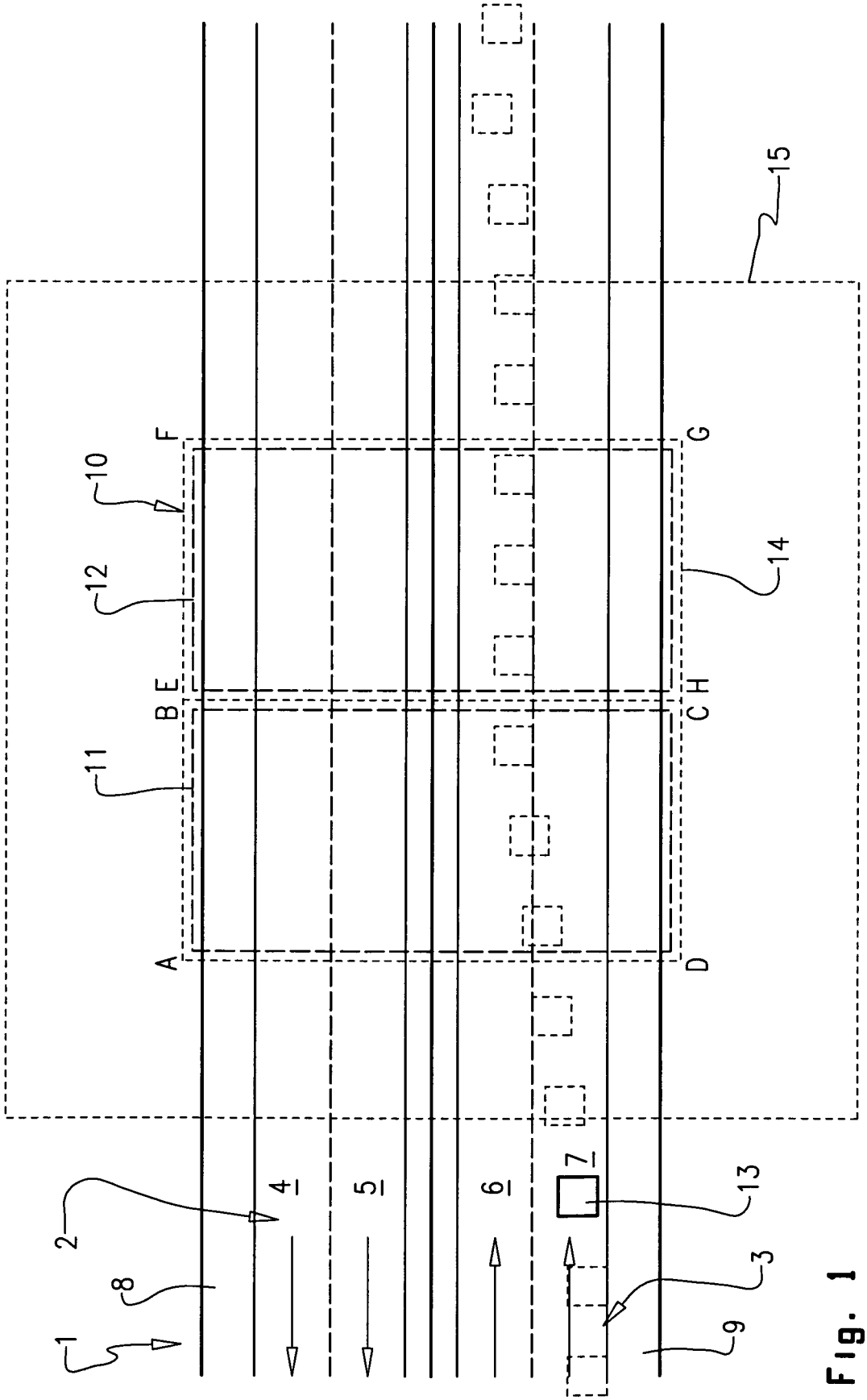

Fig. 1

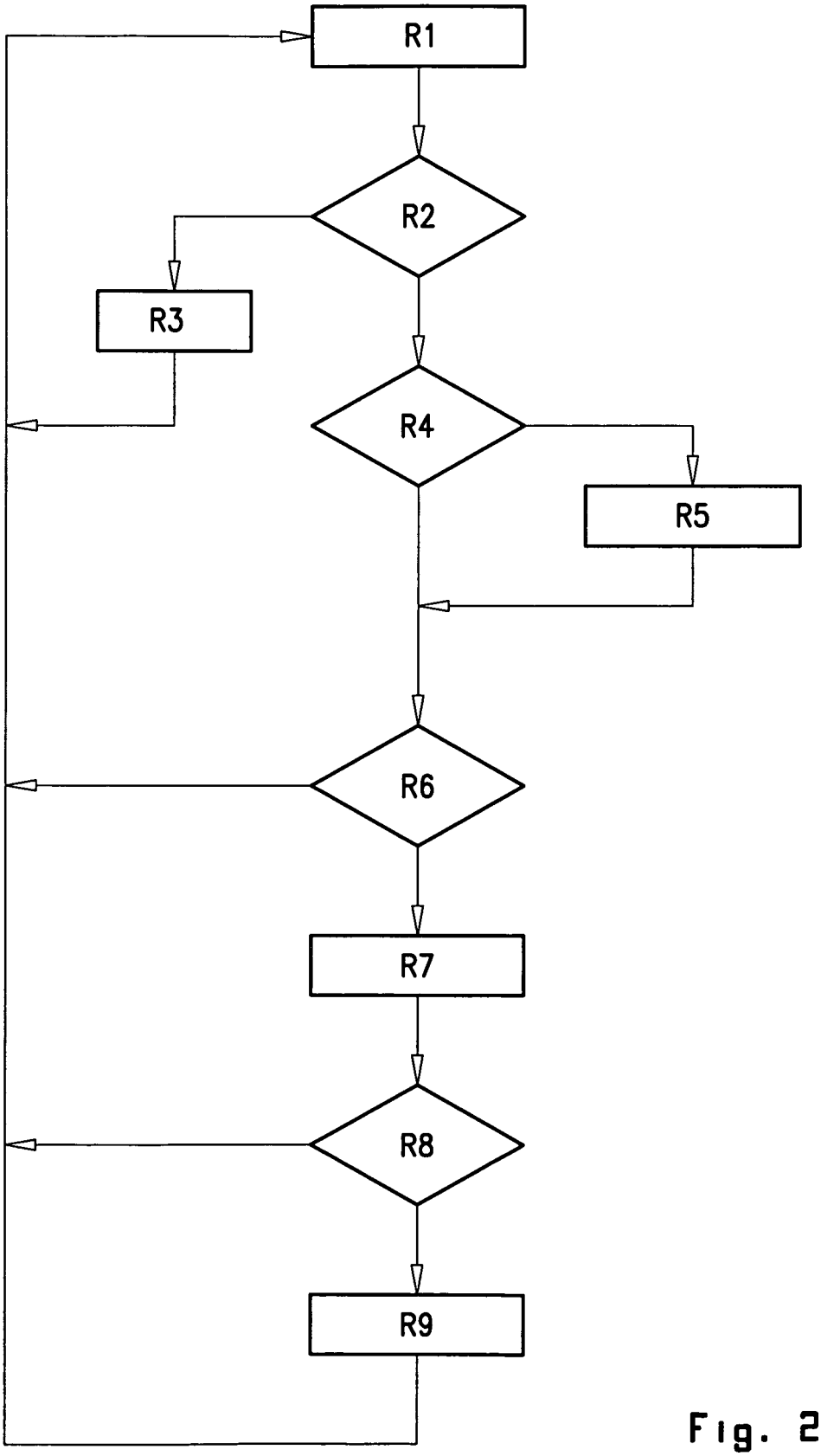

Fig. 2

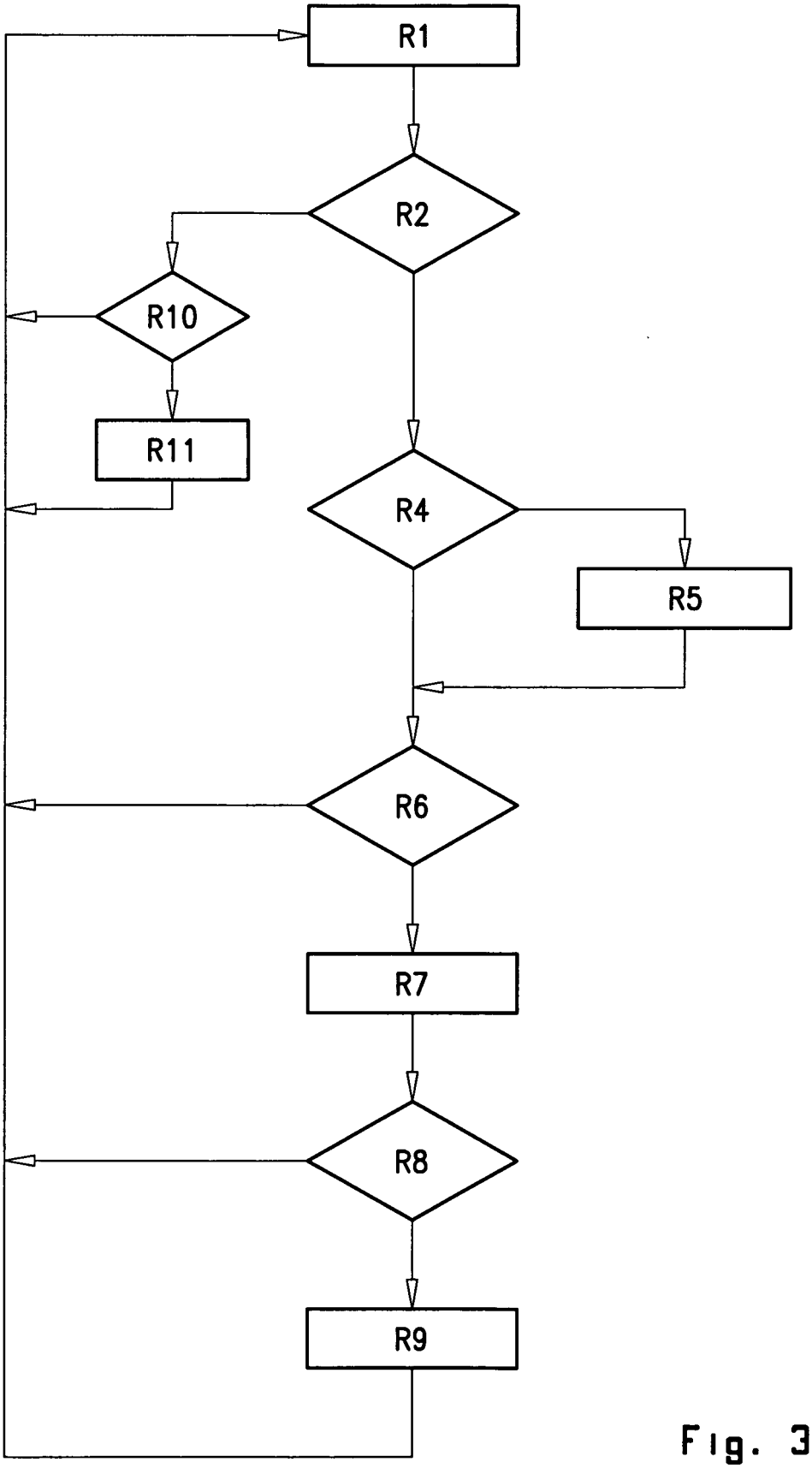

Fig. 3

REFERENCES CITED IN THE DESCRIPTION

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