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(71) Applicant: **MIMOS BERHAD** [MY/MY]; Technology Park Malaysia, 57000, Kuala Lumpur (MY).

(72) Inventors: **TING, Kee Ngoh**; Mimos Berhad, Technology Park Malaysia, 57000, Kuala Lumpur (MY). **CHIENG, Heng Tze**; Mimos Berhad, Technology Park Malaysia, 57000, Kuala Lumpur (MY). **BINTI KHALID, Putri Shahnim**; Mimos Berhad, Technology Park Malaysia, 57000, Kuala Lumpur (MY). **CHOONG, Khong Neng**; Mimos Berhad, Technology Park Malaysia, 57000, Kuala Lumpur (MY). **A/L SEBASTIAMPILLAI, Chrishanton Vethanayagam**; Mimos Berhad, Technology Park Malaysia, 57000, Kuala Lumpur (MY).

(74) Agent: **LOK, Choon Hong**; c/o Pintas Consulting Group Sdn Bhd, No. 19, Jalan Ss 1/36, 47300 Petaling Jaya, Selangor (MY).

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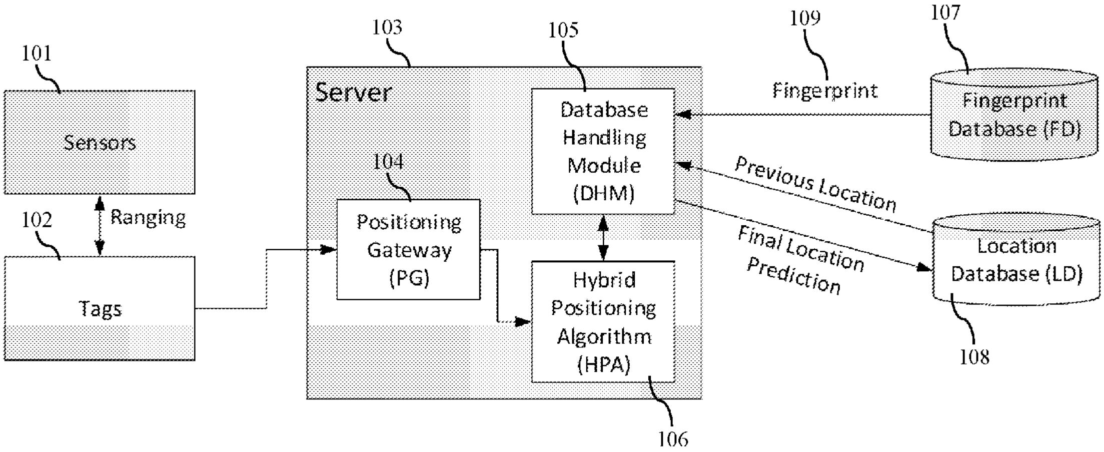
(54) **Title:** A SYSTEM AND METHOD FOR PROVIDING AN INDOOR POSITIONING TRACKING

FIG. 1



(57) **Abstract:** The present invention discloses a system for providing an indoor positioning tracking, the system is characterized by having a wireless tag (102), a database handling module (105) and a hybrid positioning algorithm module (106). The system executes the following steps: establishing a communication link with one or more sensors (101) to obtain a first predicted location through a first positioning algorithm, employing at least one second positioning algorithm to obtain a second predicted location, determining conditions of the first predicted location of the wireless tag (102) and its respective movement patterns, applying weighting adjustments to coordination values of the first and second predicted locations based on the determined conditions, and combining the adjusted coordination values of the first and second predicted locations to obtain an accurate final predicted location.

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A SYSTEM AND METHOD FOR PROVIDING AN INDOOR POSITIONING TRACKING

FIELD OF INVENTION

The present invention relates to a system and method for providing an indoor positioning tracking. More particularly, the present invention relates to a system employing at least two techniques for indoor positioning tracking and its method thereof.

BACKGROUND OF THE INVENTION

Indoor positioning systems have become increasingly wide spread and used in recent years. Systems specifically oriented towards positioning and navigation such as Global Positioning System (GPS) and location systems which operate over cellular networks like Global System for Mobile communication (GSM) and Universal Mobile Telecommunication System (UMTS) do not work properly and often suffer from large location errors when used indoors. In particular, difficulties with GPS positioning usually occur in city cores and indoors, where it is difficult to acquire the necessary number of satellites for a position computation. GPS receivers require an unobstructed view of the sky, so they are commonly used outdoors and do not perform well within forested areas or near tall buildings. Since these location systems are inefficient for indoor environments, alternative positioning technologies are required.

Many technologies related to indoor positioning have been proposed to further improve the system. For example, a United States patent with publication no. US8063820B2 discloses a hybrid positioning system and method, more specifically a system and method of integrating a wireless local area network (WLAN) based positioning system (WLAN-PS) and a satellite positioning system (SPS) to improve accuracy of location estimates by selecting the best set of measurements from both systems. According to the document, the method includes determining a wireless local area network based location estimate for a wireless local area network, and a satellite enabled device based on one or more wireless local area network access points. The document further describes the method of obtaining satellite measurements for the wireless local area network and satellite-enabled device from at least three different satellites. As such, the final location estimate is then determined using the WLAN access points and the selected set of satellite measurements.

Another United States patent with publication no. US8737279B1 discloses a method and system for position location of clients in wireless local area networks (WLAN), whereby the position location technique utilizes time-of-flight (TOF) measurements of signals transmitted from a client to a number of wireless access points or vice versa to determine the distances between them. Another technology as disclosed in United States patent with publication no. US10192416B2 recites a system and method for indoor positioning and tracking of devices and objects using a multi-band wireless networking system. In the document, multiple wireless networking devices are interconnected via a dedicated wireless backhaul to collectively form a single multi-band wireless network providing broad coverage to a client device. By coordinating the wireless networking devices via the dedicated backhaul and applying positioning processes to the received signals, a position of the client device or object is determined.

The aforementioned patent documents disclose the various systems and methods of indoor positioning by utilizing satellite-enabled mobile devices in connection with other wireless devices. However, these systems and method fail to provide an effective method of determining the location of the user in the event satellite positioning prove ineffective in deeper regions of a building.

Accordingly, it would be desirable to provide a system and method for providing an indoor positioning tracking, more particularly a system and method employing a hybrid positioning algorithm based on a combination of at least two techniques to effectively mitigate the problem highlighted above.

SUMMARY OF INVENTION

The present invention discloses a system for providing an indoor positioning tracking, the system comprising a wireless tag, configured to establish a communication link with one or more sensors to obtain a first predicted location through a first positioning algorithm; a database handling module, configured to employ at least one second positioning algorithm to obtain a second predicted location; a hybrid positioning algorithm module, configured to determine conditions of the first predicted location of the wireless tag and its respective movement patterns, apply weighting adjustments to coordination values of the first and second predicted locations based on the determined conditions, and combine the adjusted coordination values of the first and second predicted locations to obtain an accurate final predicted location.

Preferably, the system further comprising a positioning gateway module, configured to transmit information received from the wireless tag to the hybrid positioning algorithm module.

Preferably, the wireless tag applies a trilateration approach as the first positioning algorithm to obtain the first predicted location.

Preferably, the database handling module applies a fingerprint positioning technique as the second positioning algorithm to obtain the second predicted location.

Preferably, the conditions include the first predicted location is within a predefined area, the movement pattern has an illogical movement speed, the movement pattern has an illogical movement direction, or the first predicted location is in an illogical standing location.

Preferably, the database handling module is further configured to store the final predicted location in a location database and retrieve a previously predicted location from the location database for comparison with the current predicted location.

In another aspect of this invention, there is provided a method for providing an indoor positioning tracking, the method comprising the steps of: establishing a communication link with one or more sensors to obtain a first predicted location through a first positioning algorithm, by a wireless tag; employing at least one second positioning algorithm to obtain a second predicted location, by a database handling module; determining conditions of the first predicted location of the wireless tag and its respective movement patterns, applying weighting adjustments to coordination values of the first and second predicted locations based on the determined conditions, and combining the adjusted coordination values of the first and second predicted locations to obtain an accurate final predicted location, by a hybrid positioning algorithm module.

Preferably, the method further comprising the step of transmitting information received from the wireless tag to the hybrid positioning algorithm module, by a positioning gateway module.

Preferably, the first positioning algorithm is a trilateration approach to obtain the first predicted location, wherein the trilateration approach comprises the steps of determining multiple distances of the wireless tag from three of more sensors through a ranging process, and computing an average value of the distances to obtain a subsequent predicted location of the wireless tag from the sensors.

Preferably, the second positioning algorithm is a fingerprint positioning technique to obtain the second predicted location, whereby the fingerprint positioning technique comprises the steps of determining multiple distances of the wireless tag from surrounding sensors at all reference points through the ranging process, acquiring previously collected fingerprints which were stored in a fingerprint database, and computing the distances of the wireless tag from the sensors with the previously collected fingerprints from the fingerprint database to obtain a subsequent predicted location.

Preferably, the conditions include the first predicted location is within a predefined area, the movement pattern has an illogical movement speed, the movement pattern has an illogical movement direction, or the first predicted location is in an illogical standing location.

One skilled in the art will readily appreciate that the present invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. The embodiment described herein is not intended as limitations on the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of facilitating an understanding of the invention, there is illustrated in the accompanying drawing the preferred embodiments from an inspection of which when considered in connection with the following description, the invention, its construction and operation and many of its advantages would be readily understood and appreciated.

FIG. 1 is a block diagram of a system for providing an indoor positioning tracking, according to the present invention.

FIG. 2 is a flow chart illustrating an exemplary embodiment for a method for providing an indoor positioning tracking based on the above-mentioned system.

FIG. 3A illustrates a preferred embodiment for a ranging process between a wireless tag and one or more sensors.

FIG. 3B illustrates an exemplary embodiment for the ranging process with an obstacle in between the wireless tag and the sensor.

FIG. 4 illustrates a preferred embodiment of fingerprints used in a fingerprint positioning technique to obtain a second predicted location of the wireless tag.

FIG. 5 is a flow chart illustrating an exemplary embodiment of a hybrid positioning algorithm to determine a final predicted location of the wireless tag.

DETAILED DESCRIPTION OF THE INVENTION

It will be understood that each block of the flowchart illustrations and combinations of blocks in the flowchart illustrations can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, or a special purpose computer and the likes, such that the instructions that execute via the processor of the computer, create means for implementing the functions specified in the flowchart or block diagrams.

These computer program instructions may be stored in a computer-readable memory that can direct a computer or a programmable data processing apparatus to function in a specific manner, such that the instructions stored in the computer-readable memory produce an article of manufacture including instruction means that implement the functions specified in the flowchart or block diagrams.

The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer implemented process such that the instructions that execute on the computer or other programmable apparatus provide steps for implementing the functions specified in the flowchart or block diagrams.

The invention will now be described in greater detail, by way of example, with reference to the drawings.

Referring to **FIG. 1**, there is provided a system for providing an indoor positioning tracking comprising of a wireless tag **102** with an established communication link with a one or more sensors **101**, wherein the wireless tag **102** may be a mobile device such as a mobile phone capable of processing information and performing complex tasks over an established wireless network connection such as Long Term Evolution (LTE) cloud, Code Division Multiple Access (CDMA) and its derivatives, Enhanced Data Rates for GSM Evolution (EDGE), 3G protocol, High Speed Packet Access (HSPA), 4G protocol, 5G protocol and the likes, Wireless Fidelity (Wi-Fi) or Bluetooth, in accordance to the advancement of wireless technology with time. In a preferred embodiment, the sensors **101** employed are capable of performing a ranging **201** process with the wireless tag **102**, which is a process to determine the distance from one location or position to another location or position, wherein the sensors **101** may be a an infra-red (IR) distance sensors, ultrasonic sensors, a Light Detection and Ranging (LiDAR) sensor, and the likes, with each varying in range capabilities, frequencies, cost and such. In a preferred embodiment, the outcome from the ranging **201** process is transferred over to a server **103** comprising a plurality of modules **104, 105, 106**, in which these modules **104, 105, 106** may be in a form of software or hardware-based computer-implementable instructions. The server **103** may be defined as a software or hardware device that is dedicated to managing network resources. Further, the server **103** is connected to a fingerprint database **107** and location database **108** for retrieving and storing of information, wherein the databases may be an internal or external computer system in wired or wireless communication with the server **103**. Preferably, the plurality of modules **104, 105, 106** communicate with one another to form an interconnected communication network.

In one particular embodiment, the server **103** comprises a positioning gateway module **104**, configured to receive predicted locations from the wireless tag **102**. With reference to **FIG. 2**, the wireless tag **102** firstly establishes a communication link by performing the ranging **201** process with one or more sensors **101** to obtain an estimated initial location, then subsequently applies a trilateration approach **202** as a first positioning algorithm to obtain a first predicted location, in which this information is then transferred over to the positioning gateway module **104**, before being transmitted into the hybrid algorithm module **106**. The trilateration approach **202** is a common method for position calculation, whereby the trilateration approach **202** determines relative positions of objects using geometry of triangles in a similar fashion as triangulation, as illustrated in **FIG. 2**. However, unlike triangulation which uses angle measurements together with at least one known distance to calculate a subject's location, the trilateration approach **202** uses the known locations of two or more reference points and the measured distance between the subject and each reference point. In a 2-Dimensional trilateration approach **202**, the position of the subject can be accurately and uniquely determined by measuring distances from at least three reference points. Preferably, the positioning gateway module **104** works in parallel with a data handling module **105**, which will be further discussed herein.

In another preferred embodiment, the server **103** comprises the database handling module **105**, configured to employ a second positioning algorithm to obtain a second predicted location of the wireless tag **102**, wherein the second positioning algorithm is a fingerprint positioning technique **203**, such as illustrated in **FIG. 2**. Concurrently, the database handling module is further configured to retrieve a previously determined fingerprint **109** from the fingerprint database **107** to be compared with the fingerprints **109** acquired from the fingerprint positioning technique **203** and subsequently computed to obtain the second predicted location. Further, the fingerprint positioning technique **203** may be carried out in two phases, an offline phase and an online phase. The offline phase may involve pre-collecting wireless signals or Received Signal Strength (RSS) of all detected Wi-Fi access points at different reference points. As such, at each reference point, the Received Signal Strength (RSS) signature will be unique due to the spatial differences of those reference points to the surrounding access points. Hence, each reference point is then represented by a fingerprint **109**. The fingerprint **109** mentioned may include an Internet Protocol (IP) address, a Media Access Control (MAC) address or the serial number of the wireless access point router, and the likes. In addition, the online phase may involve a real time Received Signal Strength (RSS) signature to be collected and compared to the fingerprint **109** collected during the offline phase to obtain a predicted location of the wireless tag **102**. As such, calculations may be done using conventional statistical methods or by using machine learning algorithms such as K-Nearest Neighbour (KNN), Bayesian algorithm, Linear Regression, or Neural Networks and the likes. In a preferred embodiment, the database handling module is further configured to store the final predicted location calculated from the hybrid positioning algorithm module **106** in the location database **108**. Concurrently, the database handling module **105** is able to collect a previously predicted location from the location database **108** to be compared with the current predicted location of the wireless tag **102**.

In another preferred embodiment, the server **103** comprises the hybrid positioning algorithm module **106**, configured to initiate a hybrid positioning algorithm **205** upon receiving an input of the predicted locations gathered from the positioning gateway module **104** and the data handling module **105**. The hybrid positioning algorithm **205** operates by determining if the predicted locations fulfill one or more conditions, whereby the hybrid positioning algorithm **205** as in **FIG. 2** will initiate a calculation process to obtain final predicted location if any of the determined conditions are fulfilled. The final predicted location will be obtained from combining the trilateration approach **202** and fingerprint positioning technique **203** if any one of the determined conditions are fulfilled. However, if none of the determined conditions are fulfilled, the hybrid positioning algorithm **205** will then determine if the confidence level of the predicted location from using the trilateration approach **202** is high enough to be used as the final predicted location of the wireless tag **102**, which will be discussed further herein.

FIG. 2 illustrates an exemplary embodiment for a method for providing an indoor positioning tracking based on the above-mentioned system. At Step **201**, the wireless tag **102** performs a ranging **201** process with one or more sensors **101**, wherein an initial location of the wireless tag **102** is determined therewith. Step **202**and Step **203** occur in parallel, whereby the trilateration approach **202** is applied by the wireless tag **102** to obtain a first predicted location with a coordination value, t_location, and the fingerprint positioning technique **203** is applied by the database handling module **105** to obtain a second predicted location with the coordination value, f_location, by using the fingerprints **109** collected from the fingerprint database **107**. At Step **204**, the gross predicted location from both the trilateration approach **202** and the fingerprint positioning technique **203** are determined and subsequently transmitted into the hybrid positioning algorithm module **106** for further calculation. At Step **205**, the hybrid positioning algorithm **205** then initiates a series of calculations to determine a final predicted location of the wireless tag **102**, which will be discussed further herein. The steps shown in **FIG. 2** are further elaborated in **FIG. 3** to **FIG. 5**.

FIG. 3A illustrates an exemplary embodiment of the ranging **201** process between the wireless tag **102** and one or more sensors **101a, 101b, 101c, and 101d**. It should be understood that each sensor **101a, 101b, 101c,** and **101d** will perform the ranging **201** process respectively, denoted by **R**, according to the location of the wireless tag **102** from the sensors **101a, 101b, 101c,** and **101d**. As illustrated in **301**, a minimum of 3 sensors **101a, 101b, 101c,** and **101d** are required to perform the ranging **201** process with the wireless tag **102** when the wireless tag **102** is in direct line of sight relative to the sensors **101a, 101b, 101c,** and **101d**, wherein the sensors **101a, 101b, 101c,** and **101d** operate by providing necessary information for the wireless tag **102** to calculate an initial location from the ranging **201** process. In a preferred embodiment, the wireless tag **102** then calculates the first predicted location by applying the trilateration approach **202**, wherein multiple distances between the wireless tag **102** and the sensors **101a, 101b, 101c and 101d** which were determined from the ranging **201** process are computed to obtain the location of tag 102 through relative distances between tag **102** and each sensor **101a, 101b, 101c,** and **101d** denoted by **R1, R2, R3,** or **R4**.

However, as illustrated in **302 in FIG. 3B**, the accuracy of the ranging **201** process between the wireless tag **102** and the sensor **101** is greatly affected in the presence of an obstacle **303**, wherein the wireless tag **102** is no longer in direct line of sight of the sensor **101** and would have to rely on reflecting the signals off adjacent walls **304** in order for the signals to reach the wireless tag **102**, and wherein the reflected signals are denoted by **R_1**. By way of example, in indoor environments, the trilateration approach **202** suffers from a multipath and a None Line of Sight (NLOS) effect, whereby the multipath occurs when radio signals are deflected from their direct path due to reflections on obstacles **303** or walls **304**. As such, the multipath propagation of the signals causes longer times for the signals to travel between the transmitter and receiver and is especially detrimental when the None Line of Sight (NLOS) effect occurs between the wireless tag **102** and the sensors **101**, causing the direct path signal to be blocked or attenuated, resulting in the reflected signal being mistaken as a main direct path signal. As a result, any delay in the signals causes a transfer of information between the wireless tag **102** and the sensors **101** to be slower than normal, potentially causing a positioning error in the ranging **201** process, whereby the predicted location will be deviated from the true location of the wireless tag **102**.

Table 1: Collection of received signals relative to sensors

Index	Sensor1	Sensor2	Sensor3	Sensor4	...	SensorN
1	$R1_1$	$R2_1$	$R3_1$	$R4_1$	...	RN_1
2	$R1_2$	$R2_2$	$R3_2$	$R4_2$	...	RN_2
3	$R1_3$	$R2_3$	$R3_3$	$R4_3$	...	RN_3
⋮	⋮	⋮	⋮	⋮	⋮	⋮
m	$R1_m$	$R2_m$	$R3_m$	$R4_m$	...	RN_m

FIG. 4 illustrates an exemplary embodiment of the fingerprints **109** used in the fingerprint positioning technique **203** to obtain a second predicted location of the wireless tag **102**. Multiple distances from the wireless tag **102** are obtained through the collection of direct and reflected path signals by the sensors **101a, 101b, 101c,** and **101d** during the ranging **201** process as shown in **FIG. 4**, wherein each distance obtained are represented by the fingerprint **109**. . Referring to **FIG. 4**, the direct path signals are denoted by **R1, R2, R3,** and **R4** whereas the reflected path signals are denoted by **R1_1, R1_2, R2_1, R3_1, R4_1** and **R4_2**. **Table 1** refers to the representation of the fingerprint **109** of the wireless tag **102** relative to the sensors **101a, 101b, 101c,** and **101d** employed at one particular location. The fingerprints **109** of the wireless tag **102** are then subsequently collected at every location until a fingerprint map is produced. By way of example, $\mathbf{R2_1}$ represents the direct path signal of the wireless tag **102** at Sensor 2, whereas $\mathbf{R2_2}$, $\mathbf{R2_3}$ until $\mathbf{R2_m}$ represents all other reflected signal paths of the wireless tag **102** at Sensor 2, whereby the **Index 1** indicates the direct path signal for all sensors **101a, 101b, 101c,** and **101d** present in the particular location. Similarly, $\mathbf{R3_x}$ represents the collection of received signals at Sensor 3, and $\mathbf{R4_x}$ represents the collection of received signals for Sensor 4, and so forth, depending on the number of sensors **101a, 101b, 101c,** and **101d** disposed in the particular location. In a preferred

embodiment, each fingerprint **109** comprising the distance between the wireless tag **102** and the sensors **101a, 101b, 101c, and 101d** will be computed with previously collected fingerprints **109** acquired from the fingerprint database **107** to obtain the second predicted location. Preferably, newly collected fingerprints **109** will also be stored in the fingerprint database **107** for future use, whereby the issue of the reflected signals during the trilateration approach **202** can be rectified by employing the fingerprints **109** when necessary. As such, the fingerprint positioning technique **203** together with the trilateration approach **202** can therefore be used to obtain a predicted location for the wireless tag **102.**

FIG. 5 illustrates an exemplary embodiment of the hybrid positioning algorithm **205** to determine the final predicted location of the wireless tag **102** by determining conditions that needs to be met before proceeding to the next step in the hybrid positioning algorithm **205**. At Step **501**, the hybrid positioning algorithm **205** will determine whether the predicted location of the wireless tag **102** is in a predefined area. If the predicted location of the wireless tag **102** is in the predefined area, the hybrid positioning algorithm **205** will initiate a calculation process to predict the final predicted location by using an equation as illustrated at Step **502**, which is as follows:

$$\boldsymbol{\beta * t\_location + \gamma * f\_location}$$

Wherein, $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ are weightage adjustments in the hybrid positioning algorithm **205** for the coordination values of the first and the second predicted location respectively.

If the predicted location of the wireless tag **102** is not in the predefined area, the hybrid positioning algorithm **205** will determine whether the wireless tag **102** meets the next set of conditions. At Step **503**, the hybrid positioning algorithm **205** will determine whether the wireless tag **102** exhibits an illogical movement speed by moving too far or too fast within a short period of time. This condition is determined by comparing the distance of the current location of the wireless tag **102** with its previously predicted location. If the wireless tag **102** fulfills this condition, Step **507** will be initiated to calculate the final predicted location, wherein the equation is as follows:

$$\alpha * t\_location + (1-\alpha) * f\_location$$

Wherein, α and $(1-\alpha)$ are weightage adjustments in the hybrid positioning algorithm **205** for the coordination values of the first and second predicted location respectively, if the wireless tag **102** is found to fulfill any one of the determined conditions.

If the wireless tag **102** does not meet the condition at Step **503**, the hybrid positioning algorithm **205** will proceed to initiate Step **504**, whereby the hybrid positioning algorithm **205** will determine whether the wireless tag **102** has performed any illogical movement direction. Such an illogical movement direction can be characterised as, by way of example but not limited to, the wireless tag **102** passing through an obstacle **303** or an adjacent wall **304**. If the wireless tag **102** is found to have shown this, then Step **507** will be initiated. However, if the wireless tag **102** does not fulfil this condition, Step **505** shall then be initiated with a different condition to be checked. At Step **505,** the hybrid positioning algorithm **205** will determine whether the first predicted location of the wireless tag **102** is in an illogical standing location, wherein the first predicted location of wireless tag **102**, by way of example, may be within a wall or in a blind spot that prevents the wireless tag **102** from receiving signals from the sensors **101**. If the wireless tag **102** is found to have fulfilled this condition, Step **507** will subsequently be initiated. Further, Step **506** will only be initiated if none of the conditions of the first predicted location being within the predefined area, illogical movement speed, illogical movement direction, and/or illogical standing location are met. In this step, the hybrid positioning algorithm **205** will compare a confidence level of the coordination value, t_location, for the predicted location using the trilateration approach **202** with a predefined threshold. If the confidence level of the coordination value, t_location, exceeds the predefined threshold, the hybrid positioning algorithm **205** will then use the predicted location from the trilateration approach **202** as the final predicted location of the wireless tag **102** as illustrated at Step **508**. However, if the confidence level of the coordination value, t_location, is lower than the predefined threshold, Step **507** will then be initiated to obtain the final predicted location of the wireless tag **102**.

The present disclosure includes as contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred form with a degree of particularly, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangements of parts may be resorted to without departing from the scope of the invention.

CLAIMS

1. A system for providing an indoor positioning tracking, the system is characterized by having:
   a wireless tag (102), configured to establish a communication link with one or more sensors (101) to obtain a first predicted location through a first positioning algorithm;
   a database handling module (105), configured to employ at least one second positioning algorithm to obtain a second predicted location; and
   a hybrid positioning algorithm module (106), configured to:
      determine conditions of the first predicted location of the wireless tag (102) and its respective movement patterns;
      apply weighting adjustments to coordination values of the first and second predicted locations based on the determined conditions; and
      combine the adjusted coordination values of the first and second predicted locations to obtain an accurate final predicted location.

2. The system according to Claim 1, further comprising a positioning gateway module (104) configured to transmit information received from the wireless tag (102) to the hybrid positioning algorithm module (106).

3. The system according to Claim 1, wherein the wireless tag (102) applies a trilateration approach (202) as the first positioning algorithm to obtain the first predicted location.

4. The system according to Claim 1, wherein the database handling module (105) applies a fingerprint positioning technique (203) as the second positioning algorithm to obtain the second predicted location.

5. The system according to Claim 1, wherein the conditions include: the first predicted location is within a predefined area; the movement pattern has an illogical movement speed; the movement pattern has an illogical movement direction; or the first predicted location is in an illogical standing location.

6. The system according to Claim 1, wherein the database handling module (105) is further configured to store the final predicted location in a location database (108) and retrieve a previously predicted location from the location database (108) for comparison with the current predicted location.

7. A method for providing an indoor positioning tracking, the method is characterized by having the steps of:

establishing, by a wireless tag (102), a communication link with one or more sensors (101) to obtain a first predicted location through a first positioning algorithm;

employing, by a database handling module (105), at least one second positioning algorithm to obtain a second predicted location;

determining, by a hybrid positioning algorithm module (106), conditions of the first predicted location of the wireless tag (102) and its respective movement patterns;

applying, by the hybrid positioning algorithm module (106), weighting adjustments to coordination values of the first and second predicted locations based on the determined conditions; and

combining, by the hybrid positioning algorithm module (106), the adjusted coordination values of the first and second predicted locations to obtain an accurate final predicted location.

8. The method according to Claim 7, further comprising the step of transmitting, by a positioning gateway module (104), information received from the wireless tag

(102) to the hybrid positioning algorithm module (106).

9. The method according to Claim 7, wherein a trilateration approach (202) is applied as the first positioning algorithm to obtain the first predicted location, wherein the trilateration approach (202) comprises the steps of:

determining multiple distances of the wireless tag (102) from three or more sensors (101) through a ranging (201) process; and

computing an average value of the distances to obtain a subsequent predicted location of the wireless tag (102) from the sensors (101).

10. The method according to Claim 7, wherein a fingerprint positioning technique (203) is applied as the second positioning algorithm to obtain the second predicted location, wherein the fingerprint positioning technique (203) comprises the steps of:

determining multiple distances of the wireless tag (102) from surrounding sensors (101) at all reference points through the ranging (201) process;

acquiring previously collected fingerprints (109) which were stored in a fingerprint database (107); and

computing the distances of the wireless tag (102) from the sensors (101) with the previously collected fingerprints (109) from the fingerprint database (107) to obtain a subsequent predicted location.

11. The method according to Claim 7, wherein the conditions include: the first predicted location is within a predefined area; the movement pattern has an illogical movement speed; the movement pattern has an illogical movement direction; or the first prediction location is in an illogical standing location.

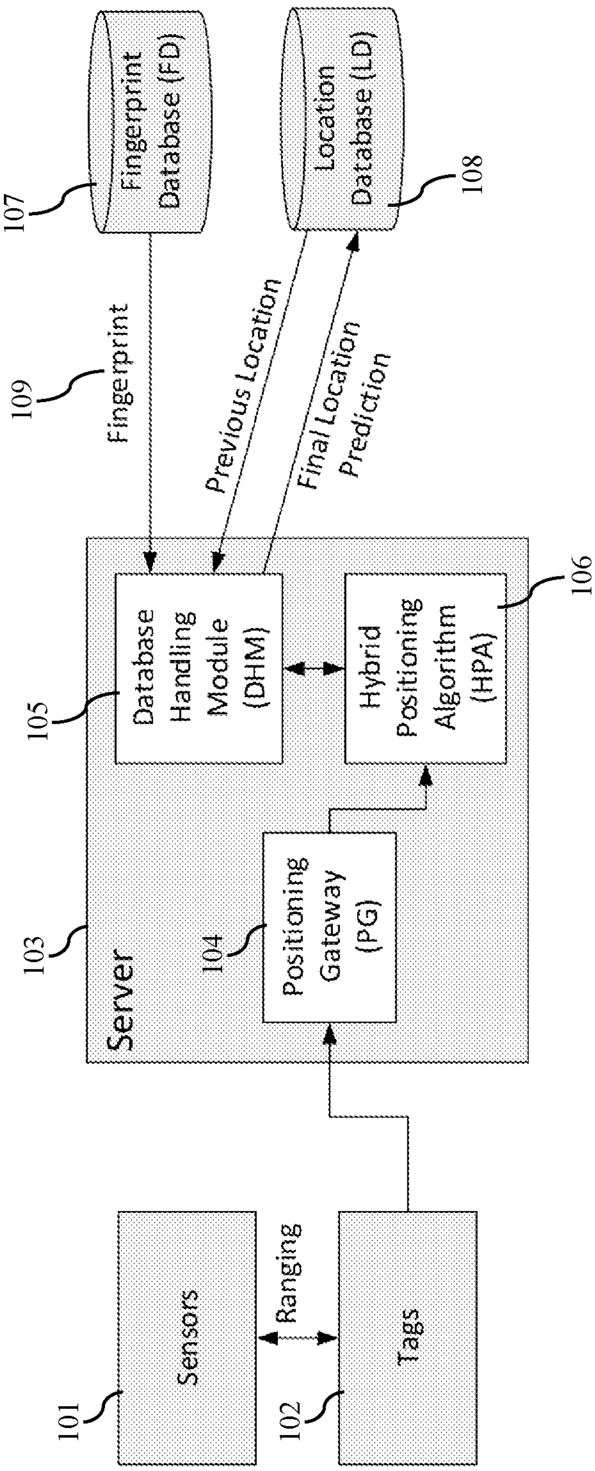
Fingerprint Database (FD)
107
Location Database (LD)
108
109
Fingerprint
Previous Location
Final Location Prediction
Database Handling Module (DHM)
105
Hybrid Positioning Algorithm (HPA)
106
Server
103
Positioning Gateway (PG)
104
Sensors
101
Ranging
Tags
102

FIG. 1

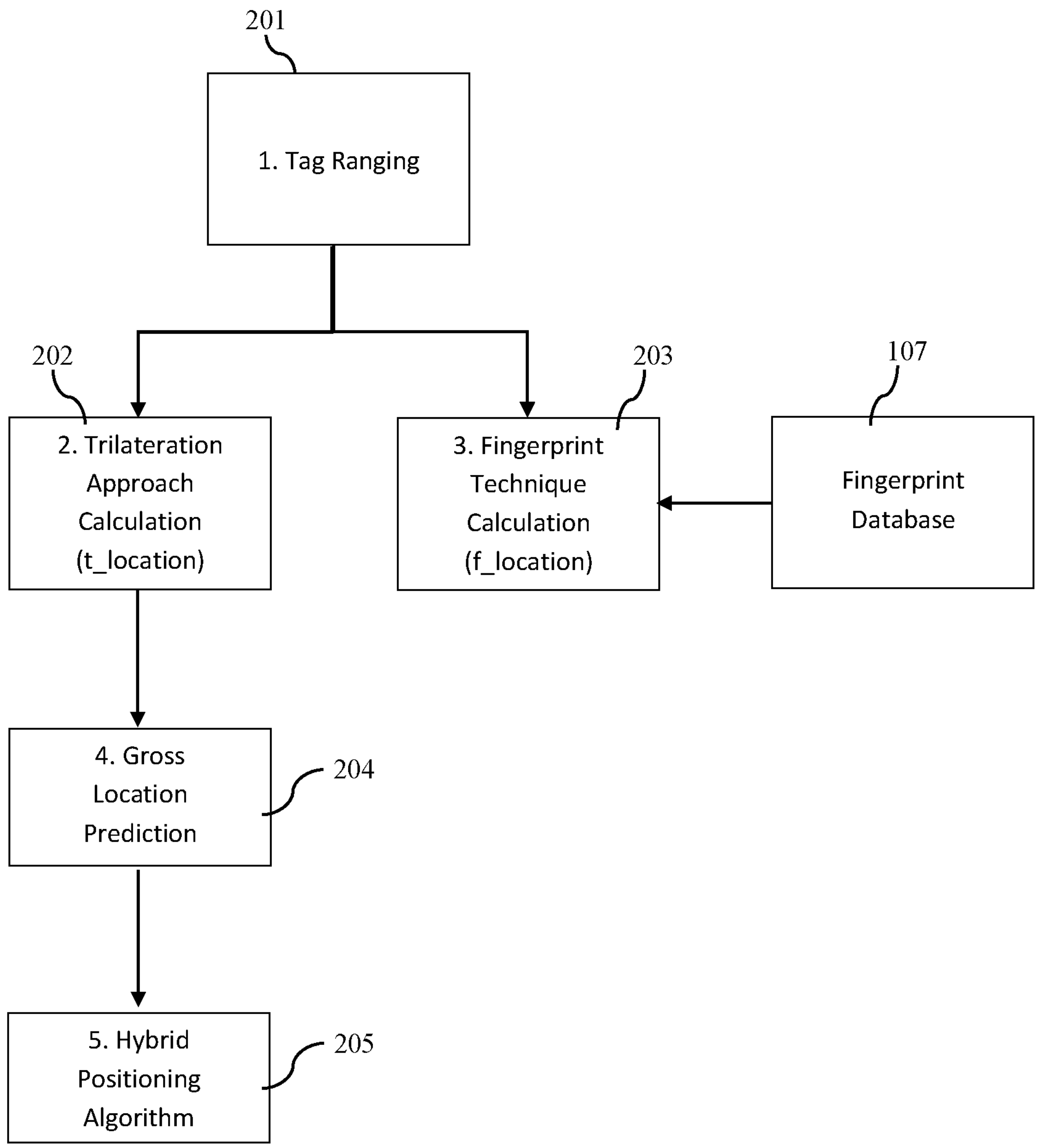
201
1. Tag Ranging
202
2. Trilateration Approach Calculation (t_location)
203
3. Fingerprint Technique Calculation (f_location)
107
Fingerprint Database
4. Gross Location Prediction
204
5. Hybrid Positioning Algorithm
205

FIG. 2

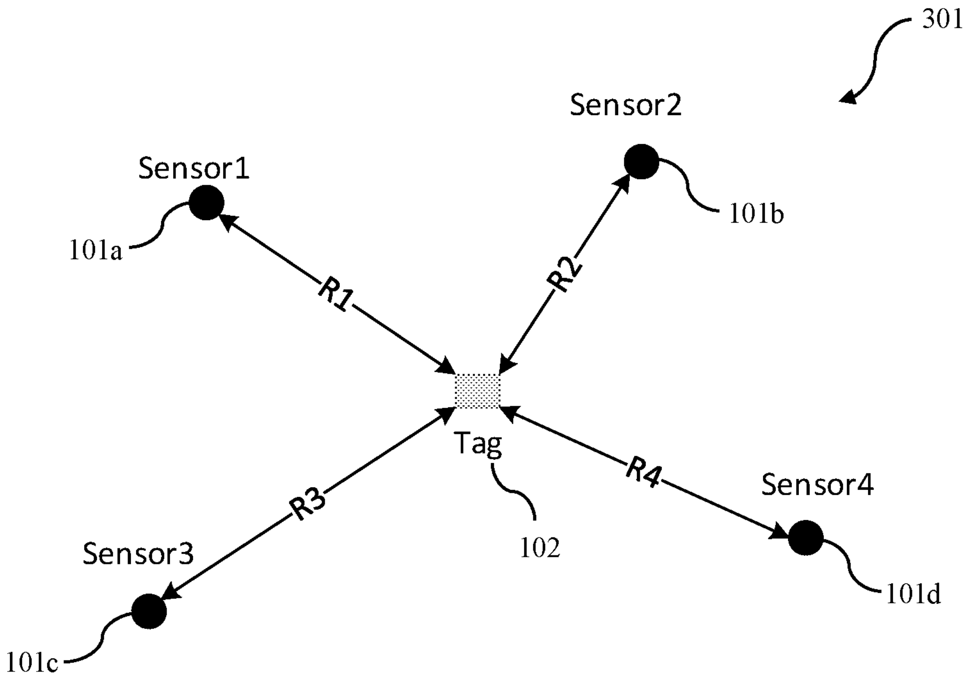
301
Sensor2
Sensor1
101b
101a
R1
R2
Tag
R3
R4
Sensor4
102
Sensor3
101d
101c

FIG. 3A

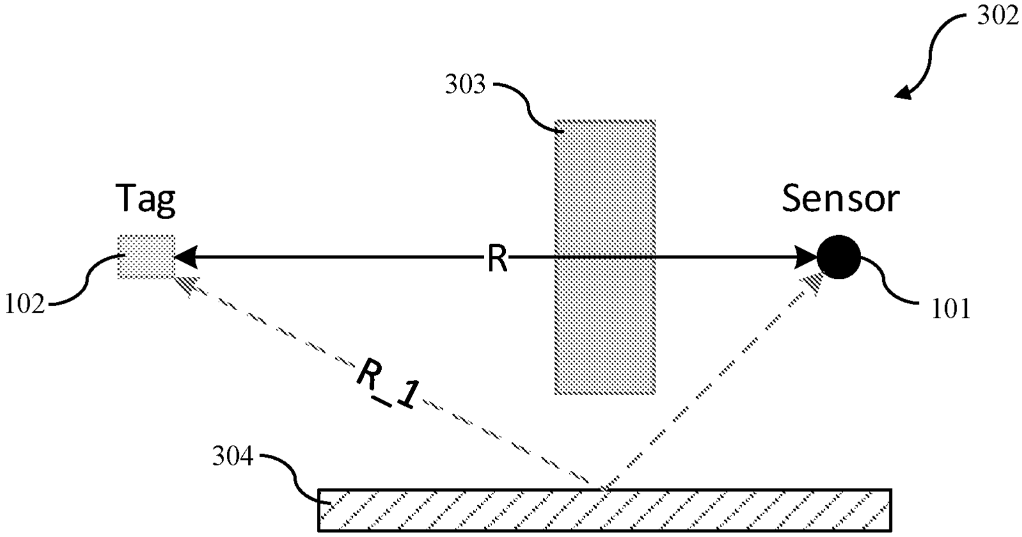
302
303
Tag
Sensor
R
102
101
R_1
304

FIG. 3B

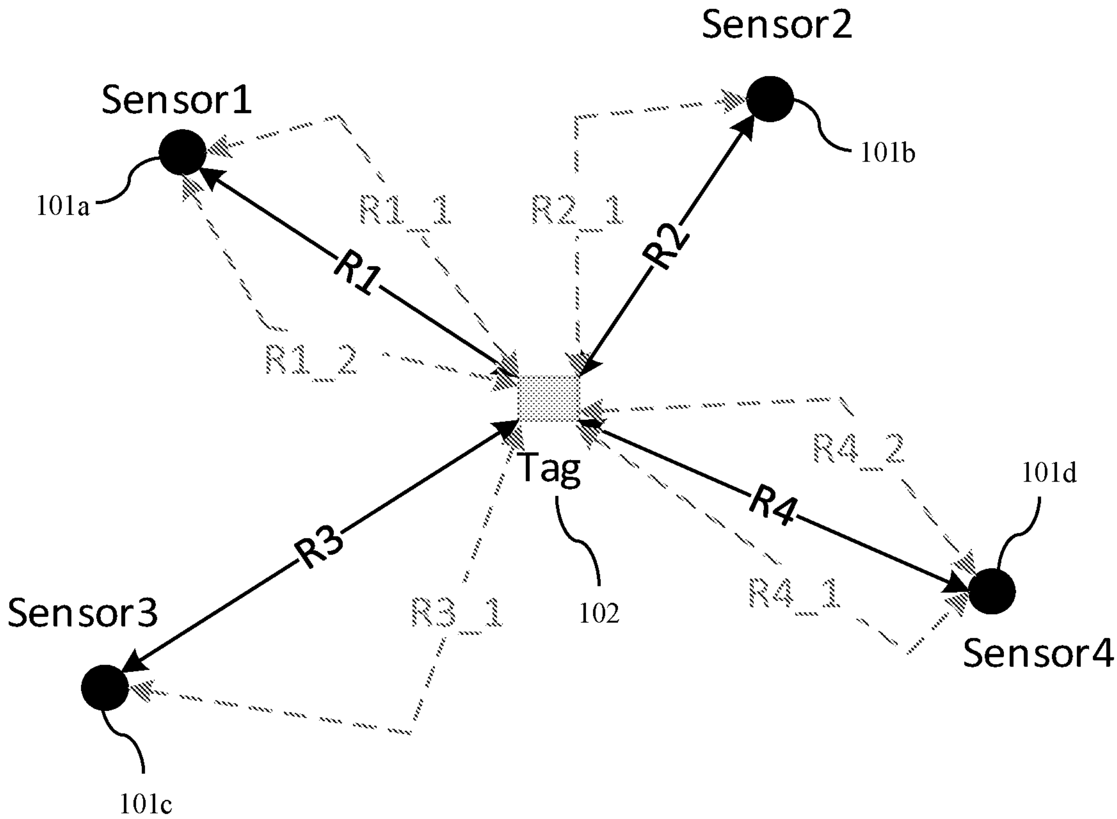
Sensor1
Sensor2
Sensor3
Sensor4
101a
101b
101c
101d
R1
R2
R3
R4
R1_1
R1_2
R2_1
R3_1
R4_1
R4_2
Tag
102

FIG. 4

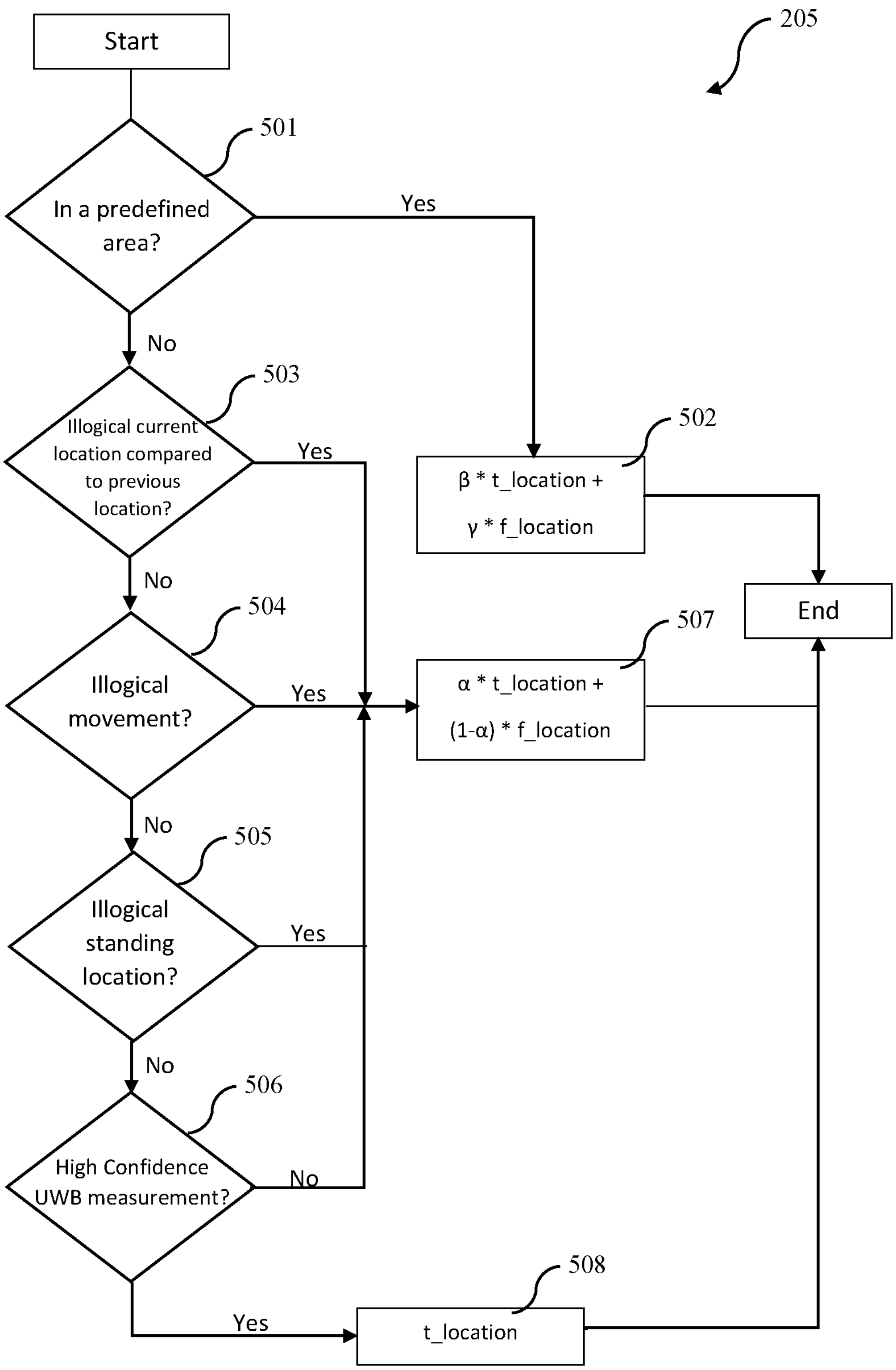
205
Start
501
In a predefined area?
Yes
No
503
Illogical current location compared to previous location?
Yes
No
502
β * t_location +
γ * f_location
End
504
Illogical movement?
Yes
507
α * t_location +
(1-α) * f_location
No
505
Illogical standing location?
Yes
No
506
High Confidence UWB measurement?
No
Yes
508
t_location

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/MY2020/050189

A. CLASSIFICATION OF SUBJECT MATTER

G01C 21/20(2006.01)i; **G01C 21/00**(2006.01)i

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)

G01C 21/20(2006.01); G01S 5/00(2006.01); G01S 5/02(2010.01); H04L 12/28(2006.01); H04W 4/02(2009.01); H04W 4/04(2009.01); H04W 40/24(2009.01); H04W 76/02(2009.01)

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

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & keywords: indoor positioning, wireless tag, trilateration, fingerprint, hybrid

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2017-0265041 A1 (HONEYWELL INTERNATIONAL INC.) 14 September 2017 (2017-09-14) paragraphs [0018]-[0040] and figures 1, 2	1-11
A	US 2015-0029945 A1 (QUALCOMM INCORPORATED) 29 January 2015 (2015-01-29) paragaphs [0025]-[0030] and figure 1	1-11
A	EP 3514564 A1 (CENTRE NATIONAL D`ETUDES SPATIALES) 24 July 2019 (2019-07-24) claims 1-3 and figure 1	1-11
A	WO 2010-059934 A2 (QUALCOMM INCORPORATED et al.) 27 May 2010 (2010-05-27) paragraphs [0059]-[0064] and figures 1-3	1-11
A	CN 106792524 A (TAIYUAN UNIVERSITY OF TECHNOLOGY) 31 May 2017 (2017-05-31) claim 1 and figures 1, 2	1-11

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "D" document cited by the applicant in the international application
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "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
18 March 2021	**18 March 2021**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office **189 Cheongsa-ro, Seo-gu, Daejeon** **35208, Republic of Korea**	**BAHNG, Seung Hoon**
Facsimile No. **+82-42-481-8578**	Telephone No. **+82-42-481-5560**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/MY2020/050189

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				WO	2015-013018	A1	29 January 2015
EP	3514564	A1	24 July 2019	CN	112041697	A	04 December 2020
				WO	2019-141849	A1	25 July 2019
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				CN	102265174	B	16 March 2016
				EP	2368131	A2	28 September 2011
				EP	2368131	B1	19 December 2012
				EP	2527860	A2	28 November 2012
				EP	2527860	A3	23 January 2013
				EP	2527861	A2	28 November 2012
				EP	2527861	A3	23 January 2013
				EP	2600165	A1	05 June 2013
				EP	2600165	B1	30 July 2014
				EP	2746802	A1	25 June 2014
				EP	2746802	B1	25 July 2018
				ES	2511190	T3	22 October 2014
				JP	2012-509483	A	19 April 2012
				JP	2013-167630	A	29 August 2013
				JP	2014-139568	A	31 July 2014
				JP	5976703	B2	24 August 2016
				KR	10-1312896	B1	30 September 2013
				KR	10-1340788	B1	11 December 2013
				KR	10-2011-0089431	A	08 August 2011
				KR	10-2012-0127526	A	21 November 2012
				TW	201037344	A	16 October 2010
				TW	201344230	A	01 November 2013
				US	2010-0135178	A1	03 June 2010
				US	2013-0223261	A1	29 August 2013
				US	2013-0237246	A1	12 September 2013
				US	9213082	B2	15 December 2015
				WO	2010-059934	A3	12 August 2010
CN	106792524	A	31 May 2017	CN	106792524	B	22 November 2019