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(71) Applicant: **SIMTEK SIMULASYON VE BILISIM TEKN. EGT. MUH. DANIS. TIC. LTD. STI.** [TR/TR]; Universiteler Mah. 1596. Cadde Safir Bloklar C Blok Ofis No.906 Kapi No.6, Beytepe, Ankara (TR).

(72) Inventors: **KULALI, Gul Meltem**; Hacettepe Teknokent Safir Bloklar C Blok Ofis No.906, Beytepe, Ankara (TR). **ARIYUREK, Sinan**; Universiteler Mah. 1596. Cadde Safir Bloklar C Blok Ofis No.906 Kapi No.6, Beytepe, Ankara (TR).

(74) Agent: **TRITECH PATENT TRADEMARK CONSULTANCY INC.**; Cankaya Mahallesi Mahmut Yesari Sokak No.8/5, 06690 Cankaya/Ankara (TR).

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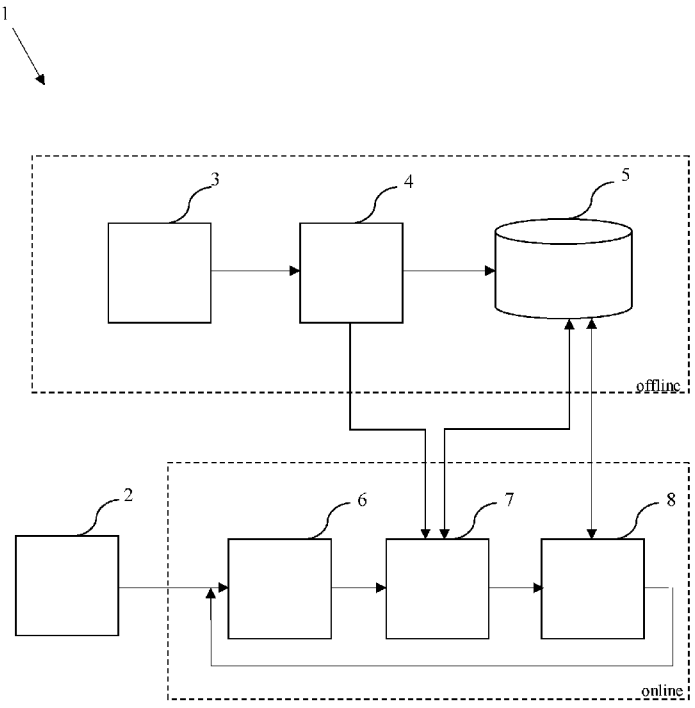

Figure 1

(57) Abstract: The present invention relates to a system (1) which determines position by using data obtained by means of sensors such as IMU (Inertial Measurement Unit) and GPS (Global Positioning System) and improves the determined position through use of high-resolution images and height data obtained from various sources and stored upon being tagged, in order to perform position determination with high accuracy.

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A SYSTEM FOR PROVIDING POSITION DETERMINATION WITH HIGH ACCURACY

Technical Field

The present invention relates to a system which determines position by using data obtained by means of sensors such as IMU (Inertial Measurement Unit) and GPS (Global Positioning System) and improves the determined position through use of high-resolution images, and height data obtained from various sources and stored upon being tagged, to perform position determination with high accuracy.

Background of the Invention

Nowadays, a variety of technologies are being developed to determine positions of persons and other living/non-living things such as car, phone, electronic device. GPS (global positioning system) and IMU (inertial measurement unit) data are used to determine the position in mobile platforms. Commercial GPS sensors which are available in mobile platforms, provide data with an optimum accuracy of approximately four meters and their performances are variable. Position information can also be obtained from the data provided by angular velocity (gyroscope) and linear acceleration (accelerometer) sensors available in the IMU. However, sensor errors increase gradually by time because of nature of position calculation. Studies based on image processing are also done by making use of cameras available in mobile devices. Minimizing margin of error in position determination methods is important for fields of usage.

The Japanese patent document no, **JP2015194397**, an application in the state of the art, discloses a vehicle location detection system. The said system comprises a map information storage unit, a vehicle location estimation unit, a line

characteristic extraction unit related to the objects encountered on the road, an imaging unit placed in the vehicle, a bird's eye view conversion unit which is configured such that it will perform conversion of each line segment into a bird's eye view, an association unit which is configured such that it will calculate angle differences between the line segments and line segments located on the map, and a location update unit which is configured such that it will update the predicted location information of the vehicle. Vehicle location estimation unit calculates the location of the vehicle by means of the image obtained by photographing a distance determined from the vehicle. The line segments expressing the contours of the objects present in the obtained image are determined; a conversion process to bird's eye view is applied for each line segment, and each converted image is compared with the GPS data.

Considering the disadvantages included in the state of the art and mentioned above; it is understood that there is need for a system which improves the position determined by using data obtained by means of sensors such as IMU (Inertial Measurement Unit) and GPS (Global Positioning System), through use of data obtained from various sources and provides to perform position determination in an up-to-date way and with high accuracy by comparing multiple data.

Summary of the Invention

An objective of the present invention is to realize a system for determining position by merging high-resolution images and height data which are obtained from various sources and stored upon being tagged and which are preferably aerial photo, with data which are obtained by means of sensors such as IMU, GPS.

Another objective of the present invention is to realize a system whereby a high-accuracy position determination is aimed by merging features extracted on images with IMU and GPS data.

Detailed Description of the Invention

"A System for Providing Position Determination with High Accuracy" realized to fulfil the objectives of the present invention is shown in the figure attached, in which:

Figure 1 is a schematic view of the inventive system for providing position determination with high accuracy.

The components illustrated in the figure are individually numbered, where the numbers refer to the following:

1. System
2. Mobile device
3. Sampling module
4. Feature extraction module
5. Data storage module
6. Position determination module
7. View conversion module
8. Optimizer module

Offline

Online

The inventive system (1) whereby the level of accuracy is increased in position determination comprises:

- at least one mobile device (2) which comprises at least one camera, at least one IMU and at least one GPS;
- at least one sampling module (3) which segments the image and height data received from external source/sources, to store it in a grid

structure through the use of sampling and tagging method depending on position;

- at least one feature extraction module (4) which determines features on the data received from external source/sources by using point of view (pov) and position as a tag;
- at least one position determination module (6) which calculates the optimum user position by using the position information that also comprises the time information obtained by the GPS located on the mobile device (2) and/or the user position information that is determined in the previous cycle, and besides determines the point of view by IMU, and receives the data that are created by the sampling module (3) and the feature extraction module (4) in accordance with the position, point of view information;
- at least one view conversion module (7) which uses the image that is received from the mobile device (2) and converts it into bird's eye view; and
- at least one optimizer module (8) which performs feature scanning depending on the point of view and position information of the user in the images that are obtained by the view conversion module (7), compares the scan results with the pre-determined features, and determines the optimum user position by determining the best matching position candidates and tagging them with their time information.

In the inventive system (1), the mobile device (2) is an electronic device such as smartphone, tablet, smart glasses that comprises at least one IMU and at least one GPS and can get image. The IMU located on the mobile device (2) comprises accelerometer, gyroscope and it can preferably comprise magnetic sensor as well.

In a preferred embodiment of the invention, the sampling module (3) uses the high-resolution height and image data provided by an external source which is

preferably an unmanned aerial vehicle (UAV-Unmanned Aerial Vehicle) and segments it by using sampling method at interchangeable intervals depending on position and point of view. A preferred sampling module (3) converts the height and image data into a grid structure. The sampling module (3) aims to store the data in the grid structure by changing the position and the point of view at certain intervals to enhance speed and accuracy in sampling process. For example, the sampling module (3) changes the point of view in 5 degrees.

In the inventive system (1), the feature extraction module (4) determines features on the image data obtained in each point of view for each position. In a preferred embodiment, the feature extraction module (4) uses methods such as BRIEF (Binary Robust Independent Elementary Features) which is a feature definition method using binary character strings during feature determination process and/or KAZE method which is a feature determination method extracting two-dimensional feature and running on non-linear scale. Since the feature extraction module (4) runs as offline, it can generate multiple databases in a preferred embodiment.

In the inventive system (1), a high-resolution (up to 25 cm) height and image data received from an external source –that is preferably UAV– by the sampling module (3) and the feature extraction module (4) running as offline, is processed in order to be stored in a structure providing speed and ease of scanning. The inventive system (1) also comprises at least one data storage module (5) wherein the feature and height data obtained as offline, tagged according to position and point of view and in the grid structure, is stored.

In the inventive system (1), the position determination module (6) determines the position where the user is located approximately by using the position information obtained from GPS, in online system. The position determination module (6) takes into account the optimum user position determined in the previous cycle and compares the position information received from GPS and the optimum user

position calculated in the previous cycle, if the position determination process is not carried out for the first time. The position determination module (6) also evaluates the time difference, the distance and the GPS error together with GPS data between two positions in the comparison process. Thereby, the position determination module (6) decides whether to use "the calculated optimum user position information" or "the position information obtained from GPS". The position determination module (6) uses the optimum user position information in the event that the result is "the calculated optimum user position is within the circle created when the GPS error is accepted as radius" in the comparison process. The position determination module (6) uses the data obtained by GPS when it decides that the result is "the calculated optimum user position is a larger position change depending on the user's speed" in the comparison process. The position determination module (6) uses up-to-date GPS data if the calculated optimum user position time information is far older than time information in the GPS data.

The position determination module (6) determines the tags that it will search in the data prepared by the sampling module (3) by taking into account the error amounts of angle and position according to the point of view calculated with IMU and the position information determined. The position determination module (6) receives the data suitable for these (determined) tags from the data that are prepared in the sampling module (3) and the feature extraction module (4) and stored in the data storage module (5) by using the tags. As the amount of error decreases, the amount of data received from the sampling module (3) and the feature extraction module (4) by the position determination module (6) will also decrease in the offline part.

In a preferred embodiment of the invention, the view conversion module (7) converts the image that is received from the mobile device (2) in online system, into bird's eye form by using "Bird's Eye View" method. The "Bird's Eye View" method that is used by the view conversion module (7) is the conversion of a

known camera point of view into a top-facing camera point of view. The mobile device (2) is expected to get image such that position information will be seen as much as possible, in order that the view conversion module (7) can perform the conversion process properly. The view conversion module (7) performs a process by taking account of the fact that it is not located on a flat surface in the view conversion process, when it decides that it is not located on a flat surface in accordance with the information received from the IMU.

In the inventive system (1), the optimizer module (8) compares the features that it found according to the point of view and position information in the place where the user is located with the features found previously, in online system. For this process, the optimizer module (8) is in communication with the feature extraction module (4) or at least one data storage module (5) wherein the feature and height data obtained as offline, tagged according to position and point of view are stored. The optimizer module (8) thus determines the best matching position candidate/candidates and tags it/them with the time whereto it/they belong. The optimizer module (8) applies feature extraction and comparison processes on the next incoming camera images as well and chooses the most matching set according to consecutive images in the event that there are multiple candidates. Thereby, the optimizer module (8) determines the point where the user is located with minimum error and time information. The optimizer module (8) transmits the calculated user position and time tag to the position determination module (6) again to compare it with GPS information.

In a preferred embodiment, the optimizer module (8) compares the pre-determined features with the features that are found possible, by a search algorithm optimized according to the user's point of view and position because it approximately knows the position where the user is located and his/her point of view.

In a preferred embodiment of the inventive system (1), the mobile device (2) may comprise a depth sensor that generates a depth map, in order to enhance the

position accuracy further. The depth map generated enhances the accuracy of the position that is calculated by overlapping the depth map and the height map of the region in the tagging process. Besides, the depth information ensures that the search is made with a correct tag while searching with a tag by determining the height of the person to the ground.

With the inventive system (1) for providing position determination with high accuracy, it is ensured that position of a person can be determined more precisely by using aerial photography and height data from a UAV (Unmanned Aerial Vehicle). After deciding on where is the user located in the height map according to the position information –that is obtained from GPS information– where the user is located; it is enabled by means of the inventive system (1) to extract feature in the image obtained by converting the image received from camera into a bird's eye view and to compare the features with these features obtained as offline, and to determine the optimum position of the user with minimum error and by being tagged with time information. Thus, the user position information can be calculated with high accuracy.

It is possible to develop various embodiments of the inventive system (1) for providing position determination with high accuracy; the invention cannot be limited to examples disclosed herein, and it is essentially according to claims.

CLAIMS

1. A system (1) whereby the level of accuracy is increased in position determination; **comprising**

- at least one mobile device (2) which comprises at least one camera, at least one IMU and at least one GPS;

characterized by

- at least one sampling module (3) which segments the image and height data received from external source/sources, to store it in a grid structure through the use of sampling and tagging method depending on position;
- at least one feature extraction module (4) which determines features on the data received from external source/sources by using point of view and position as a tag;
- at least one position determination module (6) which calculates the optimum user position by using the position information that also comprises the time information obtained by the GPS located on the mobile device (2) and/or the user position information that is determined in the previous cycle, and besides determines the point of view by IMU, and receives the data that are created by the sampling module (3) and the feature extraction module (4) in accordance with the position, point of view information;
- at least one view conversion module (7) which uses the image that is received from the mobile device (2) and converts it into bird's eye view; and
- at least one optimizer module (8) which performs feature scanning depending on the point of view and position information of the user in the images that are obtained by the view conversion module (7), compares the scan results with the pre-determined features, and determines the optimum user position by determine the best matching position candidates and tagging them with their time information.

2. A system (1) according to Claim 1; **characterized by** the mobile device (2) which is an electronic device such as smartphone, tablet, smart glasses that comprises at least one IMU and at least one GPS and can get image.

3. A system (1) according to Claim 1 or 2; **characterized by** the sampling module (3) which uses the high-resolution height and image data provided by an external source that is preferably an unmanned aerial vehicle (UAV-Unmanned Aerial Vehicle) and segments it by using sampling method at interchangeable intervals depending on position and point of view.

4. A system (1) according to any of the preceding claims; **characterized by** the sampling module (3) which aims to store the data in the grid structure by changing the position and point of view at certain intervals to enhance speed and accuracy in sampling process.

5. A system (1) according to any of the preceding claims; **characterized by** the feature extraction module (4) which uses the point of view and position information as tag and determines features in the image data obtained in each point of view.

6. A system (1) according to any of the preceding claims; **characterized by** the feature extraction module (4) which uses methods such as BRIEF (Binary Robust Independent Elementary Features) which is a feature definition method using binary character strings during feature determination process and/or KAZE method which is a feature determination method extracting two-dimensional feature and running on non-linear scale.

7. A system (1) according to any of the preceding claims; **characterized by** the feature extraction module (4) which can generate multiple databases because it runs in offline manner.

8. A system (1) according to any of the preceding claims; **characterized by** the sampling module (3) and the feature extraction module (4) which process a high-resolution (up to 25 cm) height and image data received from an external source –that is preferably UAV– in order to be stored in a structure providing speed and ease of scanning.

9. A system (1) according to any of the preceding claims; **characterized by** at least one data storage module (5) wherein the feature and height data obtained as offline, tagged according to position and point of view and in the grid structure, is stored.

10. A system (1) according to any of the preceding claims; **characterized by** the position determination module (6) which determines the position where the user is located approximately by using the position information obtained from GPS, in online system.

11. A system (1) according to any of the preceding claims; **characterized by** the position determination module (6) which takes account of the optimum user position determined in the previous cycle and compares the position information received from GPS and the optimum user position calculated in the previous cycle, if the position determination process is not carried out for the first time.

12. A system (1) according to any of the preceding claims; **characterized by** the position determination module (6) which evaluates the time difference the distance, and the GPS error together with GPS data between two positions in the comparison process.

13. A system (1) according to Claim 12; **characterized by** the position determination module (6) which decides whether to use the optimum user position information or the position information obtained from GPS.

14. A system (1) according to Claim 12 or 13; **characterized by** the position determination module (6) which uses the calculated optimum user position information in the event that the result is "the calculated optimum user position is within the circle created when the GPS error is accepted as radius" in the comparison process.

15. A system (1) according to Claim 12 or 13; **characterized by** the position determination module (6) which uses the data obtained by GPS when it decides that the result is "the calculated optimum user position is a larger position change depending on the user's speed" in the comparison process.

16. A system (1) according to Claim 12 or 13; **characterized by** the position determination module (6) which uses up-to-date GPS data if the calculated optimum user position time information is far older than time information in the GPS data.

17. A system (1) according to any of the preceding claims; **characterized by** the position determination module (6) which determines the tags that it will search in the data prepared by the sampling module (3) by taking into account the error amounts of angle and position according to the point of view calculated by IMU and the position information determined.

18. A system (1) according to Claim 17; **characterized by** the position determination module (6) which receives the data suitable for these (determined) tags from the data that are prepared in the sampling module (3) and the feature extraction module (4) by using the tags.

19. A system (1) according to any of the preceding claims; **characterized by** the view conversion module (7) which converts the image that is received from

the mobile device (2) in online system, into bird's eye form by using "Bird's Eye View" method.

20. A system (1) according to any of the preceding claims; **characterized by** the view conversion module (7) which performs a process by taking account of the fact that it is not located on a flat surface in the view conversion process, when it decides that it is not located on a flat surface in accordance with the information received from the IMU.

21. A system (1) according to any of the preceding claims; **characterized by** the optimizer module (8) which compares the features that it found according to the point of view and position information in the place where the user is located with the features found previously, in online system.

22. A system (1) according to Claim 21; **characterized by** the optimizer module (8) which is in communication with at least one data storage module (5) wherein the feature and height data obtained as offline, tagged according to position and point of view are stored by the feature extraction module (4).

23. A system (1) according to any of the preceding claims; **characterized by** the optimizer module (8) which applies feature extraction and comparison processes on the next incoming camera images as well and chooses the most matching set according to consecutive images in the event that there are multiple candidates.

24. A system (1) according to any of the preceding claims; **characterized by** the optimizer module (8) which transmits the calculated user position and time tag to the position determination module (6) again in order to compare it with GPS information.

25. A system (1) according to any of the preceding claims; **characterized by** the mobile device (2) which may comprise a depth sensor that charts a depth map, in order to enhance the position accuracy further.

Figure 1