GENERAL INFORMATION

Title: System and Methodology for a Community-Based, High-Accuracy Positioning Service Using a Network of Global Navigation Satellite System (GNSS) Receivers

Applicant Name: Fazecast, Inc. (as Assignee)

Application Type: Provisional

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Entity Status: Small Entity Status under 37 CFR 1.27

SYSTEM AND METHODOLOGY FOR A COMMUNITY-BASED, HIGH-ACCURACY POSITIONING SERVICE USING A NETWORK OF GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) RECEIVERS

Cross-Reference to Related Patent Applications

Some references, which may include patents, patent applications, and various publications, are cited and discussed herein. The citation and/or discussion of such references is not an admission that any such reference is "prior art" to the systems and methods described herein. All references cited and discussed in this disclosure are incorporated herein by reference in their entireties and to the same extent as if each reference was individually incorporated by reference. In terms of notation, hereinafter, "[n]" represents the n^{th} reference cited in the reference list.

Background

Global Navigation Satellite Systems (GNSS) are a relatively new technology, with the Global Positioning System (GPS) – the earliest and most well-known of these systems – becoming fully operational in only 1995 [1]. Since that time, an immense amount of research has been dedicated to bringing the highest possible level of accuracy to the largest number of users worldwide. At the time of this writing, the GPS specification promises worldwide absolute positioning at a level of 7.8 meters within a 95% confidence level for any single GPS receiver [2].

While this level of accuracy is quite impressive, it is inadequate for a large number of location-dependent, high-precision, or safety-critical applications, including autonomous navigation, formation flying, collision avoidance, land surveying, construction, precision agriculture, and any number of other applications not listed here. In order to increase the achievable precision of GPS, prior research has been carried out using multiple receivers to mitigate the errors common to measurements from the same satellites or in similar geographic regions. Some examples of this research include:

Source [3]: "GPS and GPS-RTK: A Comparison"

Source [4]: "USGS Global Positioning System, GPS Applications and Surveying Methods"

Source [5]: PCT Patent Application: "Method and System for High-Accuracy Differential Tracking of Global Positioning System (GPS) Receivers"

A common theme to the majority of existing solutions is the mitigation of measurable errors using *correction* data as determined by a single *reference* receiver for all mobile receivers in its loosely-defined local area. In most cases, this involves setting up and pre-surveying the precise position of a stationary receiver at some point in time, usually with a very expensive, highly-accurate timekeeping mechanism, and then allowing this receiver to compare its own satellite measurements to their respective *expected* measurements, given the receiver's known location and timing information. From this analysis, the receiver can determine a lump amount of error in each satellite measurement and transmit this error to all receivers in the vicinity so that they can mathematically remove the error before carrying out their own respective localization procedures.

These techniques, including Differential GPS (DGPS) and the Wide Area Augmentation System (WAAS) have dramatically increased the precision of GPS to single meters of error; however, their usage requires setting up an extremely expensive stationary receiver at an ideal location with a wide view of the sky, pre-surveying the exact location of this receiver – a lengthy process in itself – and transmitting via a custom-defined radio signal error corrections which are not guaranteed, or even likely, to be 100% valid for receivers in the local vicinity.

An additional set of techniques known as Real-Time Kinematic (RTK) surveying takes a similar approach, however, these techniques increase precision by carrying out differential mathematical operations on the raw satellites measurements between a reference receiver and a number of mobile receivers in the vicinity. Since the corrections are carried out using raw measurements, the level of accuracy achievable using this technique is much better than with DGPS – on the order of centimeters – however, in all embodiments producing absolute coordinates (and most producing relative coordinates), it still requires setting up, pre-surveying,

and calibrating an expensive stationary receiver and transmitting data over custom, application-specific radio frequencies.

As such, the state of the art leaves a notable gap between the accuracy achievable by a GPS-based localization service and both the cost and complexity of implementing and using that service. Therefore, an unaddressed need exists to overcome these inadequacies and deficiencies and to provide a methodology to bridge the aforementioned gap.

Brief Summary

The systems and methods described herein include a new method for community-based, high-accuracy position localization in the cloud. In one embodiment, this method includes providing a reference network having a plurality of stationary GNSS receivers at known locations, a plurality of roving GNSS receivers at unknown locations, a cloud-based service configured for bilateral communication with the plurality of GNSS receivers, transmission of raw satellite measurements in the form of carrier phases and/or pseudoranges from the GNSS receivers to the cloud, processing of the raw satellite measurements in the cloud from a plurality of stationary GNSS reference receivers and one or more roving GNSS receivers to derive the relative locations of the roving receivers with respect to one or more stationary receivers, conversion of these relative locations into absolute Earth coordinates, and transmission of the resulting coordinates from the cloud server to each receiver requesting localization.

Under an embodiment, each receiver is equipped with a GNSS chip configured to measure raw satellite measurement data including, but not limited to, the pseudorange and carrier phase of the GNSS signal.

Under an embodiment, all GNSS receivers, whether serving as a reference receiver or a roving receiver at an unknown location, provide symmetrical architectures in terms of the data they provide and transmit to the cloud server. Determination of the absolute positions of each reference receiver are carried out via user interaction-free self-calibration.

Under an embodiment, the reference network is community-owned and operated, with its establishment taking place via crowdsourcing. Participation in the establishment of this network is monetarily incentivized. The reference network provides local, regional, nationwide, or global coverage.

Under an embodiment, the localization procedure taking place in the cloud operates on streams of data from one roving receiver and one or more stationary reference receivers, wherein the data sets being used for localization at a single time step must come from the same time epochs and from receivers located in similar geographic regions.

Under an embodiment, the localization procedure operates on mathematical manipulation of the raw satellite measurements from multiple receivers and not on correction data.

Under an embodiment, data from multiple stationary receivers and a single roving receiver may be used in a multi-receiver optimization algorithm for increased localization accuracy and reliability.

Under an embodiment, the output of localization for a single roving receiver at a single time step is the relative location of the roving receiver, relative to one or more of the stationary reference receivers. This relative location may be translated into absolute Earth coordinates utilizing knowledge of the absolute position of one or more of the stationary reference receivers.

Under an embodiment, the resulting relative coordinates or the absolute Earth coordinates of the roving receiver requesting localization are transmitted from the cloud server to the roving receiver that initiated the localization request.

In summary, the advantages provided by the systems and methods described herein include operating directly on streams of raw satellite measurements instead of error correction data for increased accuracy, decreased complexity due to the symmetrical nature of the data transmission architecture with respect to both the stationary reference network and the roving network of GNSS receivers, establishment of the stationary reference network via crowdsourcing and its continued usage via monetary (or otherwise) incentives, self-calibration of the reference

network for increased transparency of the technology to end users, and a cloud-based localization approach for centralized processing, increased computing power, and ease of development by allowing any form of standardized wireless data transmission in place of custom radio transmitters and/or radio frequencies.

These and other aspects of the systems and methods described herein will become apparent from the following disclosure material taken in conjunction with the disclosed drawings, although variations and modifications therein may be affected without departing from the spirit and scope of the novel concepts of the disclosure.

Brief Description of the Drawings

Fig. 1 shows the symmetrical data transmission architecture, under an embodiment.

Fig. 2 shows a graphical representation of the pseudorange GNSS measurement observation, under an embodiment.

Fig. 3 shows a graphical representation of the carrier phase GNSS measurement observation, under an embodiment.

Fig. 4 shows a flowchart of a data transmission process, under an embodiment.

Fig. 5 shows an embodiment of data interfaces into and out of a localization procedure for a single roving receiver.

Fig. 6 shows a graphical representation of a relative-to-absolute coordinate conversion process, under an embodiment.

Fig. 7 shows a flowchart of the complete data path and localization service, under an embodiment.

Fig. 8 shows data interfaces into and out of the localization procedure for a single roving receiver with external inputs including out-of-network GNSS reference receivers and additional sensing modalities, under an embodiment.

Detailed Description

The systems and methods described herein relate generally to embodiments of a Global Navigation Satellite System (GNSS), including but not limited to the Global Positioning System (GPS), Galileo, the Global Navigation Satellite System (GLONASS), and the BeiDou Navigation Satellite System (BDS). More particularly, the disclosed embodiments relate to systems, methods and methodologies for community-based, high-accuracy positioning services utilizing signals from such GNSS services.

Under one embodiment, the architecture of the systems and methods described herein comprises a network of GNSS receivers in bilateral communication with a centralized cloud server. The network can be divided into two sub-categories consisting of 1) a stationary, reference network containing a plurality of GNSS receivers at known locations (the "reference network"), and 2) a plurality of mobile GNSS receivers at unknown locations. As shown in Fig. 1, the data type and format provided by the receivers in both categories is the same, creating a symmetrical data transmission architecture.

The absolute Earth coordinates of each of the receivers in the reference network are known based on a self-calibration procedure that each reference receiver undergoes upon power-up. Each receiver in either network is equipped with a GNSS chip configured to measure and output raw satellite observation data including, but not limited to, the pseudorange (Fig. 2) and carrier phase (Fig. 3) of the GNSS signal. Transmission of these raw satellite measurements from receiver to the cloud server may occur at fixed time intervals, as a bulk transfer, or as the data becomes available.

The reference network of GNSS receivers is established via crowdsourcing, whereby individuals opt-in to place one or more receivers that they own in a stationary location of their choosing, so long as the location has consistent access to an Internet connection. Participation in this reference network is incentivized by monthly cash payouts to each participating individual based on the amount of data that is consumed by the positioning service stemming from their individual device.

Each individually owned and operated reference device that is in service is able to provide reference data for localization of an infinite number of roving devices at unknown positions anywhere within a 100 mile range of the stationary receiver. As such, a relatively small number of stationary nodes in operation across any country may provide complete network coverage for the entire nation.

The positioning service provides high-accuracy location information to individual roving receivers by operating on raw satellite measurement data originating from the requesting roving receiver itself along with raw satellite measurements from one or more of the GNSS receivers in the reference network. In order for the localization procedure to succeed, the data sets from both the roving and the reference receivers must be aligned in time. Additionally, data from a reference receiver can only be used in the localization procedure if the receiver from which it originated lies in a similar geographic region (i.e. within 100 miles) of the roving receiver requesting a position.

Once a position for the roving receiver has been successfully determined, it is transmitted back to the requesting receiver. Fig. 4 shows a flowchart indicating the transmission process by which the localization procedure is carried out. In this illustration, the GNSS chips are producing raw measurements once per second. Every time a measurement is made, it is transmitted to the cloud server, regardless of which type of receiver made the measurement. In the case of a reference receiver, the data is simply stored in a database on the server. In the case of a roving receiver, the data is transmitted, the localization procedure is carried out, and the resulting location of the roving receiver is transmitted back to the receiver.

More specifically, each time an observation is made by any GNSS receiver, the data is corrected for any satellite-based errors and then extrapolated to a pre-defined common time epoch [5]. For example, in our illustration, each receiver makes a measurement approximately once per second. The localization procedure would then extrapolate the measurement data to coincide to what it should have been if it had been made *exactly* at the delineation of a single second according to GPS time. In such a way, all data from the same "epoch" will always

correspond to the exact same moment in time. This extrapolated measurement data is then transmitted to the cloud.

If the transmitted data originated from a roving receiver requesting a position update, then the cloud server matches the incoming data to the data sets from one or more reference receivers in a similar geographic region and then passes these matched data sets on to the localization procedure, as shown in Fig. 5. The localization procedure produces coordinates *relative* to one or more of the stationary reference receivers. In this illustration, the cloud server translates these relative coordinates into absolute Earth coordinates by adding the relative 3D position vector to the known 3D coordinates of one of the stationary receivers used in the localization procedure. This is shown in Fig. 6.

Once the relative-to-absolute coordinate conversion is complete, the resulting coordinates are transmitted back to the originating roving receiver. The flowchart for this entire process is depicted in Fig. 7. It is important to note that the localization procedure itself must operate directly on the raw measurement data from two or more GNSS receivers, not on correction data as is standard in DGPS algorithms.

It is also possible to include augmenting data from additional sensing sources, as shown in Fig. 8, including, but not limited to, on-board sensors such as inertial measurement units (IMUs) and barometers, data from satellite-based augmentation systems (SBAS), or even out-of-reference-network GNSS receivers to improve the accuracy of the localization procedure; however, inclusion of this data is optional. Additionally, it is possible to post-process the calculated locations from multiple in-network receivers in a multi-receiver optimization algorithm for increased accuracy and reliability, but again, this step is not required.

Use-Cases, Implementations, and Examples

1) Golf: Golf players and/or golf courses may use a service based on the present technology to track the location of each hole, along with the relative position of a golfer and his ball, to much greater accuracy than current distance-measuring devices or green-reading techniques used in the game today.

2) Team Sports Player Tracking (Paintball, Football, Soccer, etc.): Players on a team are equipped with a wearable device on their helmets or shoulder pads while playing. Coaches may analyze their movements in real-time or after the game/training session to evaluate the performance of the players and/or the team.

3) Extreme Sports/Performance Tracking (Skiing, Mountain Biking, Climbing, Paragliding, etc.): Sports enthusiasts can utilize the systems and methods described herein to track their paths, elevations, speeds, and other relevant metrics to much better precision than current methodologies.

4) Precision Agriculture: Precision location awareness is paramount for precision agriculture in which autonomous farming and/or localized crop monitoring is used to increase crop yields.

5) Personal Drones/UAVs/Formation Flying: Drones and other Unmanned Aerial Vehicles (UAVs) require much better precision than regular GPS to navigate in urban environments, to land on a runway, or to fly in formation with other such vehicles. Current precise GPS technologies are too expensive for low-cost vehicles to utilize.

6) Driverless Cars/Collision Avoidance: In intelligent transportation, there is a need for low-cost, precise localization, either in absolute terms or for vehicles relative to one another. Embodiments described herein may be utilized to provide accurate absolute *and* relative locations to vehicles to aid in platoon formation, collision avoidance, lane changing, etc.

7) Insurance At-Fault Detection/Accident Reconstruction: The systems and methods of embodiments described herein to determine the trajectories of vehicles before, during, and after an accident to identify the at-fault parties.

8) Land Surveying: Land surveying services are extremely expensive. When one does not require the extreme precision of professional land surveying equipment, the systems and

methods described herein can provide an easy-to-use solution for land-owners to perform DIY land surveying on their own property at a fraction of the cost.

9) Other embodiments of the present technology may include quality assurance services, personal tracking, large-scale logistics for amusement parks, music festivals, etc., crowd control, or even safety-critical location-based services.

Embodiments described herein includes a method for high-accuracy position localization comprising a ground-based reference network with a plurality of stationary GNSS receivers at known locations (the "reference network"), a plurality of roving GNSS receivers at unknown locations, a cloud-based service configured for bilateral communication with the plurality of GNSS receivers, configuration of the plurality of ground-based, stationary GNSS reference receivers to make raw satellite measurements in the form of carrier phases and/or pseudoranges, to process these measurements, and to transmit these measurements to the cloud service, configuration of the plurality of roving GNSS receivers to make raw satellite measurements in the form of carrier phases and/or pseudoranges, to process these measurements, and to transmit these measurements to the cloud service, processing by the cloud service of the raw satellite measurements from a plurality of stationary GNSS reference receivers and one or more roving GNSS receivers to derive the relative locations of the roving receivers with respect to one or more stationary receivers, optional conversion of the relative roving receiver locations into absolute Earth coordinates using knowledge of the absolute positions of one or more of the stationary GNSS reference receivers, and transmission of the resulting coordinates from the cloud service to the roving GNSS receiver to which it corresponds.

The reference network of an embodiment may be community-owned and operated, or privately-owned and operated.

The reference network of an embodiment may be established via crowdsourcing.

Each receiver of an embodiment includes a GNSS chip configured to measure raw satellite measurement data including the pseudorange and carrier phase of the GNSS signal.

The architecture of an embodiment is symmetrical in terms of the data provided by the reference network and the roving nodes.

Each stationary reference receiver, the method of an embodiment comprises determination of its initial absolute position via user interaction-free self-calibration.

For each stationary reference receiver, the method of an embodiment comprises determining the initial absolute position of the receiver utilizing a trilateration-based approach.

For each stationary reference receiver, the method of an embodiment comprises determining the initial absolute position of the receiver utilizing a time-synchronization-based approach.

The reference network of an embodiment may provide one or more of local coverage, regional coverage, nationwide coverage, and global coverage.

. Participation in the crowdsourcing effort of an embodiment may be incentivized.

The incentives of an embodiment includes one or more of monetary incentives based on fixed rates, monetary incentives based on resource utilization and non-monetary incentives.

Under an embodiment, a step of processing the measured raw satellite data for each receiver at each time epoch comprises correction of the measurement data for satellite-based errors, extrapolation of the measurement data to a pre-defined "common" time epoch, transmission from the reference receiver to the cloud server of the ephemeris data and storage of this data on the cloud server, transmission of the measurement data for the given epoch, matching by the cloud server of measurement data from one roving receiver and one or more reference receivers for the same time epoch and a similar geographic region, and passing of the matched measurement data sets to the localization procedure.

The localization procedure of an embodiment taking place in the cloud operates on streams of data from one roving receiver and one or more stationary reference receivers.

The data sets of an embodiment being used for localization come from the same time epoch and from receivers located in similar geographic regions.

Similar geographic regions of an embodiment may be defined as regions in which the maximum distance between the roving receiver and any stationary receiver taking part in the localization is no more than 100 miles.

The selection of the data sets and associated receivers of an embodiment to be used in any given localization procedure is carried out automatically based on the proximity of the roving node to one or more stationary nodes.

The localization procedure of an embodiment operates on mathematical manipulation of raw satellite measurements from multiple receivers and not on correction data.

Data from external sources of an embodiment may be used to augment the localization procedure including data from additional sensors such as IMUs or barometers, data from satellite-based augmentation systems (SBAS), data from out-of-reference-network GNSS receivers,

Data from multiple stationary receivers and a single roving receiver of an embodiment may be used in a multi-receiver optimization algorithm for increased localization accuracy and reliability.

The output of the localization procedure of an embodiment at a single time epoch is the relative location of a roving receiver, relative to one or more of the stationary reference receivers.

The resulting location information of an embodiment is held as private data on the cloud server, with no outside access to the information except by the roving receiver requesting the localization.

The relative location of an embodiment may be translated into absolute Earth coordinates by the addition of the 3D relative position vector to the known 3D coordinates of one of the stationary receivers used in the localization procedure.

The resulting coordinates, either absolute or relative or both, of the roving receiver of an embodiment requesting localization are transmitted from the cloud server to the roving receiver that initiated the request.

The systems and method for a community-based, high-accuracy positioning service using a network of global navigation satellite system receivers (GNSS) receivers are merely illustrative. Other arrangements may be employed in accordance the embodiments set forth herein. Further, variations of such systems and methods may comply with the spirit of the embodiments disclosed herein.

References

[1] E. D. Kaplan and C. J. Hegarty, Understanding GPS: Principles and Applications, Norwood, MA: Artech House, Inc., 2006.

[2] United States Department of Defense, "Global Positioning System Standard Positioning Service Performance Standard," US DoD, 2008.

[3] C. E. Allison, "GPS and RTK-GPS: A Comparison," 31 October 2011. [Online]. Available: http://ezinearticles.com/?GPS-and-RTK-GPS:-A-Comparison&id=6642248.

[4] United States Geological Survey GPS Committee, "USGS Global Positioning System, GPS Applications and Surveying Methods," US Government, 3 September 2014. [Online]. Available: http://water.usgs.gov/osw/gps/index.html. [Accessed September 2014].

[5] W. Hedgecock, M. Maroti, P. Volgyesi, J. Sallai and A. Ledeczi, "Method and System for High-Accuracy Differential Tracking of Global Positioning System (GPS) Receivers". PCT Application No. US2014/014702, 4 February 2014.

Claims

What is claimed is:

1. A method comprising:

providing one or more stationary GNSS receivers at a known location;

the one or more stationary GNSS receivers receiving and processing satellite data, the one or more stationary GNSS receivers transmitting the processed satellite data to a remote server;

one or more roving GNSS receivers receiving and processing satellite data;

a roving GNSS receiver of the one or more roving GNSS receivers requesting positioning information from the remote server, the requesting the positioning information including transmitting the processed data of the roving GNSS receiver to the remote server;

one or more applications running on at least one processor of the remote server determining the positioning information using the processed data of the one or more stationary GNSS receivers and the processed data of the roving GNSS receiver, the positioning information comprising a position of the roving GNSS receiver relative to the one or more stationary GNSS receivers.

Abstract

A method comprises providing one or more stationary GNSS receivers at a known location. The one or more stationary GNSS receivers receive and process satellite data, the one or more stationary GNSS receivers transmitting the processed satellite data to a remote server. One or more roving GNSS receivers receive and process satellite data. A roving GNSS receiver of the one or more roving GNSS receivers requests positioning information from the remote server, the requesting the positioning information including transmitting the processed data of the roving GNSS receiver to the remote server. One or more applications running on at least one processor of the remote server determines the positioning information using the processed data of the one or more stationary GNSS receivers and the processed data of the roving GNSS receiver. The positioning information comprising a position of the roving GNSS receiver relative to the one or more stationary GNSS receivers.

Figures

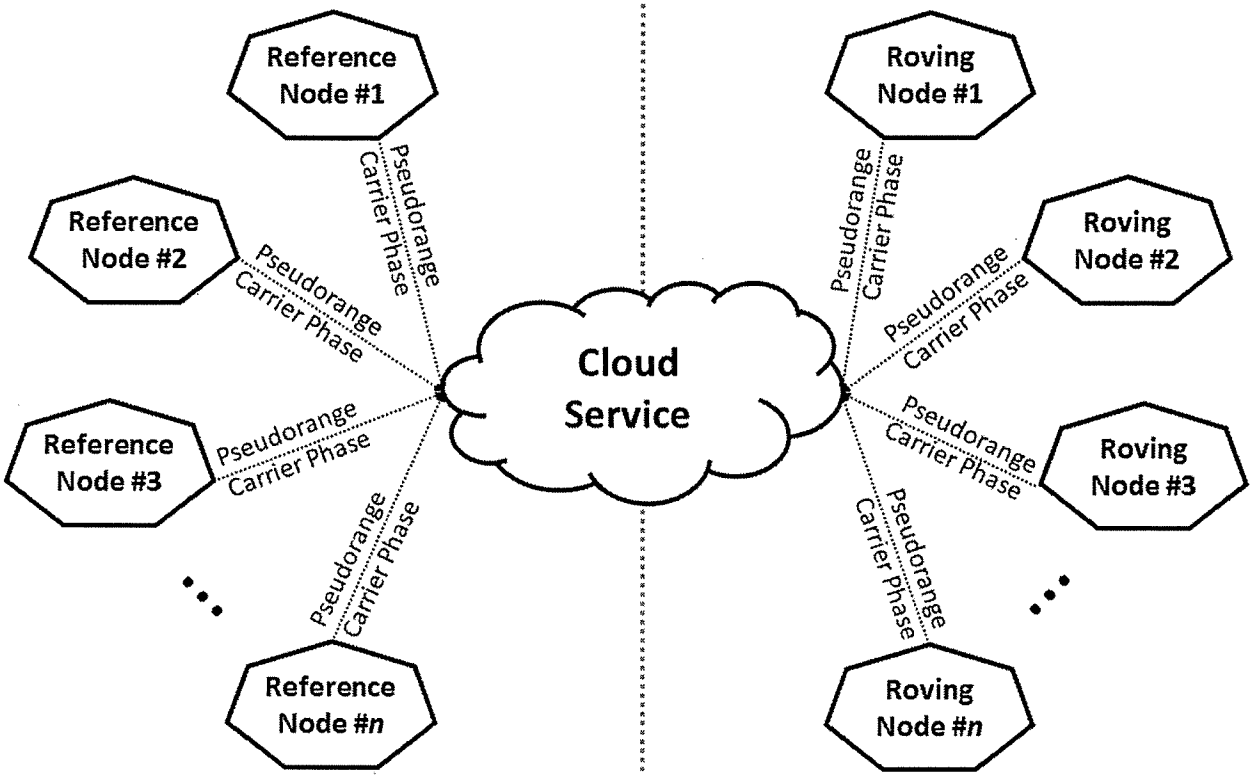


Fig. 1

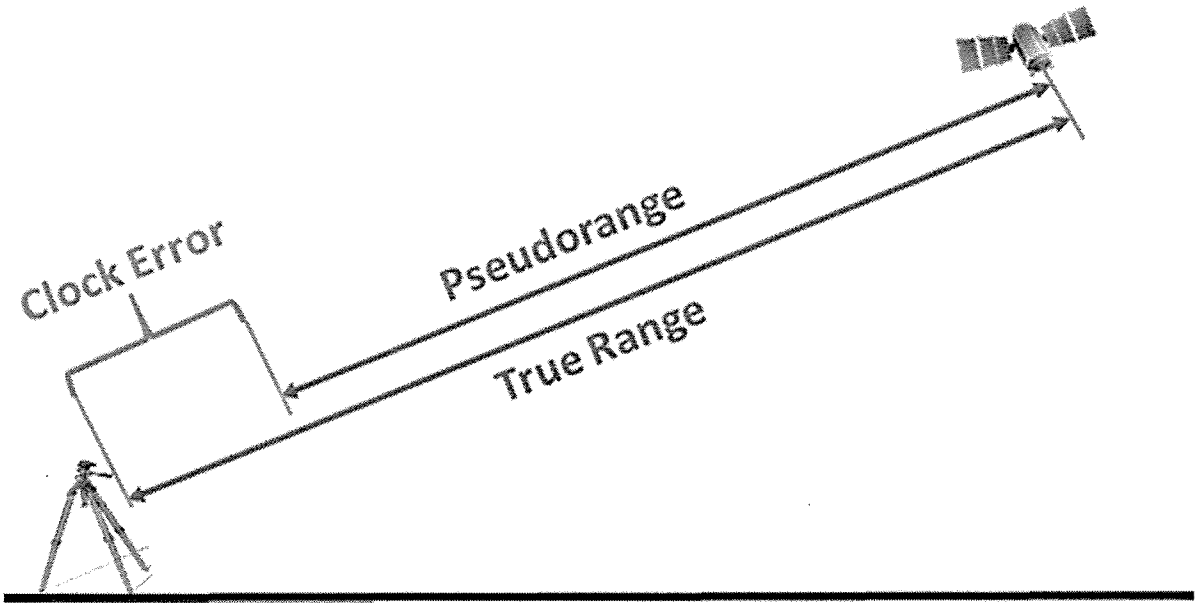


Fig. 2

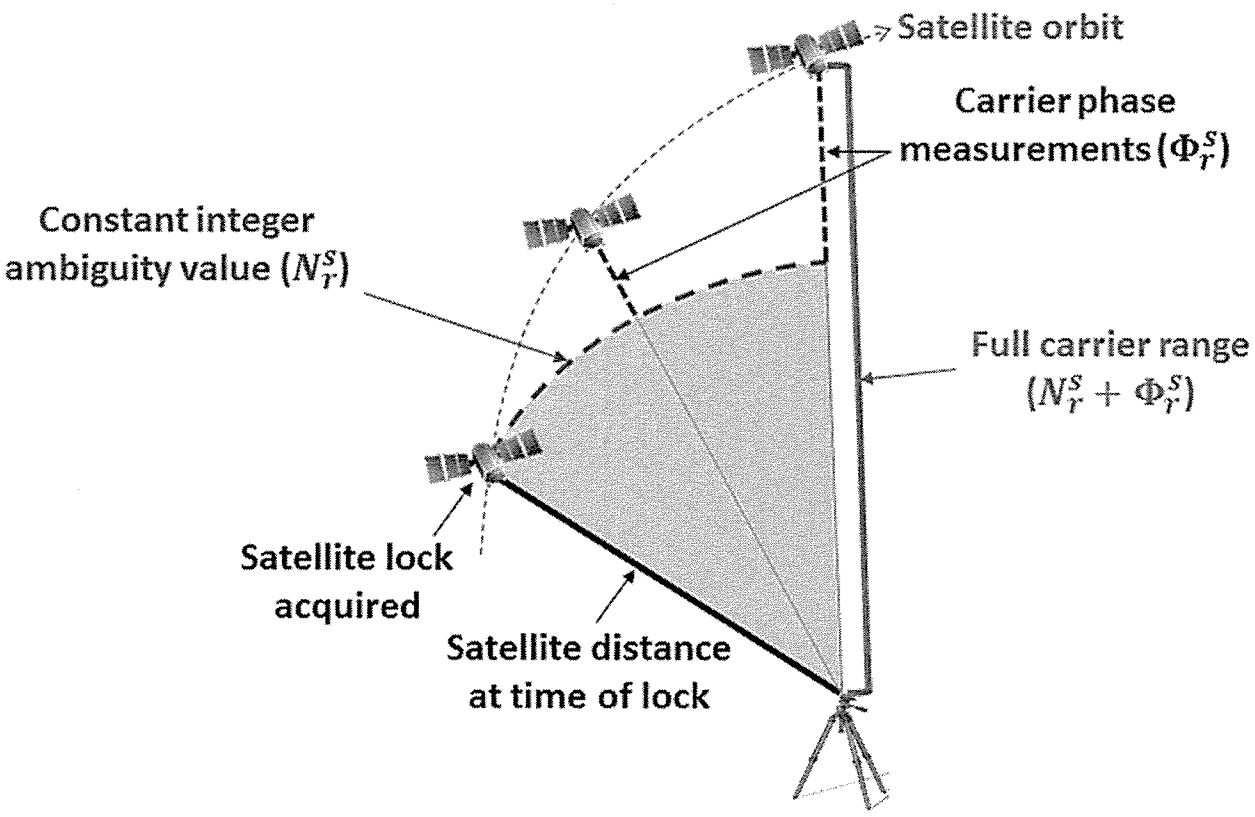

Satellite orbit
Carrier phase measurements (Φ_r^S)
Constant integer ambiguity value (N_r^S)
Full carrier range ($N_r^S + \Phi_r^S$)
Satellite lock acquired
Satellite distance at time of lock

Fig. 3

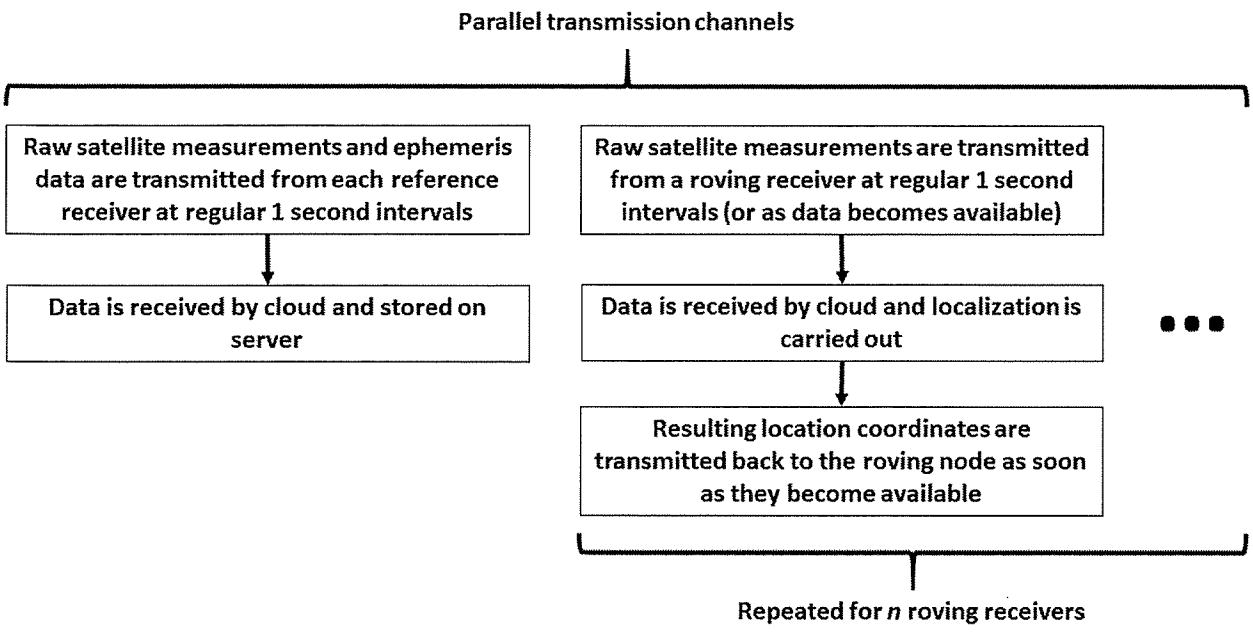

Parallel transmission channels
Raw satellite measurements and ephemeris data are transmitted from each reference receiver at regular 1 second intervals
Data is received by cloud and stored on server
Raw satellite measurements are transmitted from a roving receiver at regular 1 second intervals (or as data becomes available)
Data is received by cloud and localization is carried out
Resulting location coordinates are transmitted back to the roving node as soon as they become available
Repeated for n roving receivers

Fig. 4

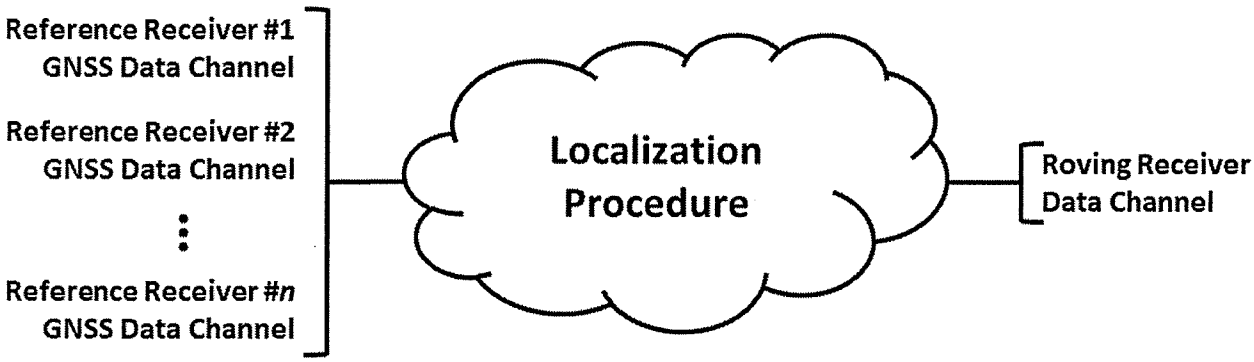
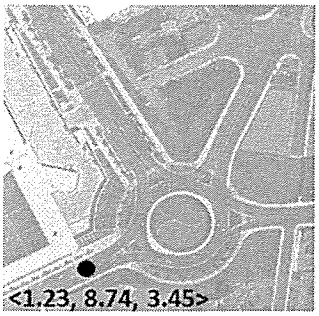
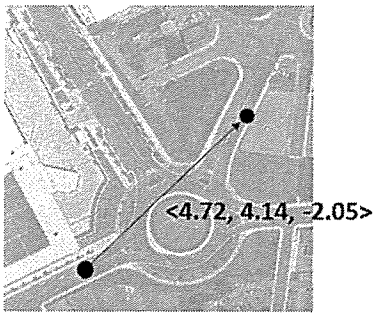

Reference Receiver #1
GNSS Data Channel
Reference Receiver #2
GNSS Data Channel
Reference Receiver #n
GNSS Data Channel
Localization
Procedure
Roving Receiver
Data Channel

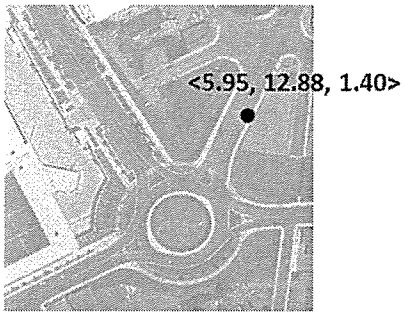
Fig. 5



Satellite map overlay with reference receiver shown at an arbitrary absolute location



3D position vector of a roving receiver relative to the reference receiver as output by the localization procedure



Absolute location of the roving receiver as determined by adding the relative position vector to the absolute location of the reference

Fig. 6

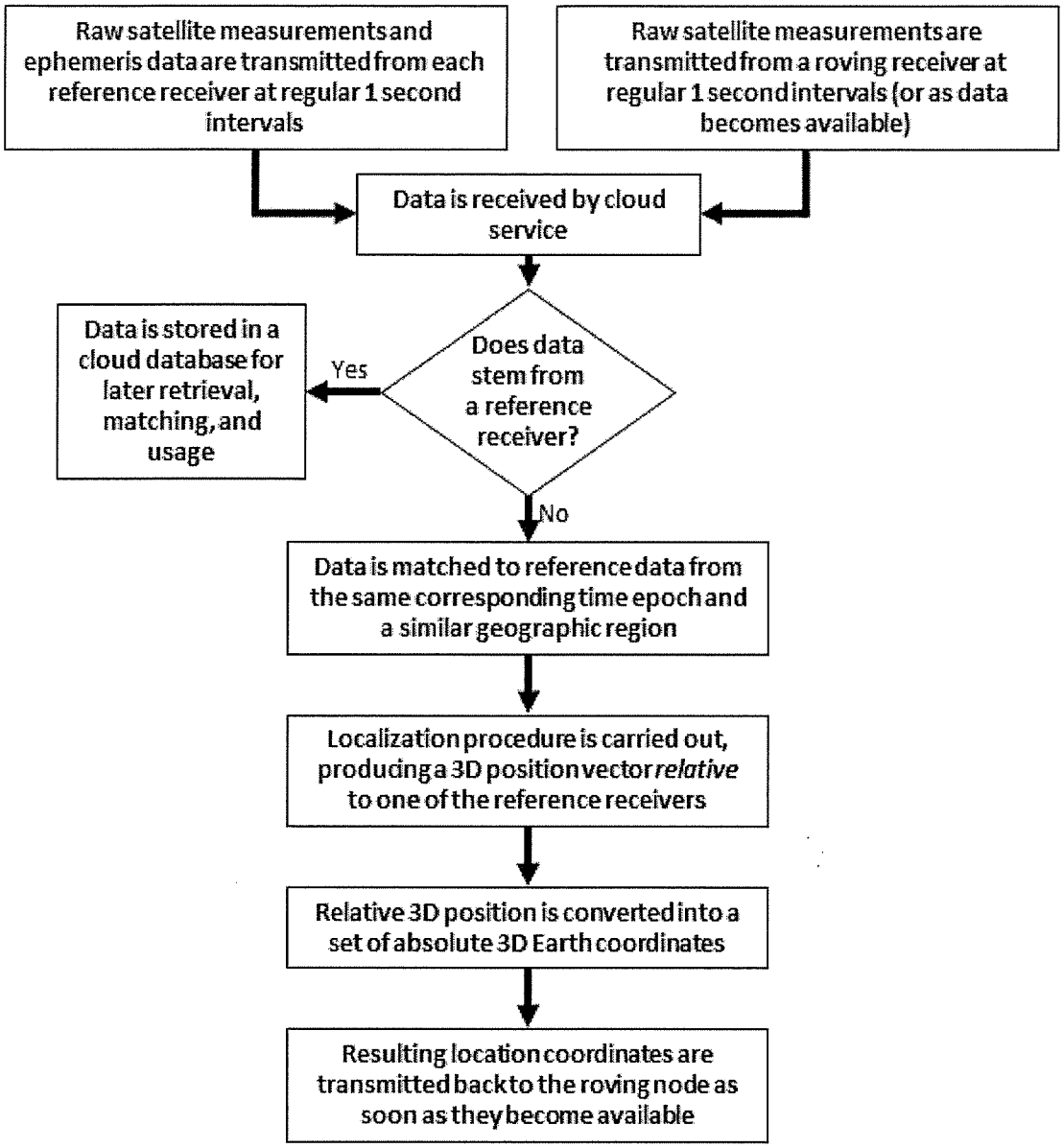

Raw satellite measurements and ephemeris data are transmitted from each reference receiver at regular 1 second intervals
Raw satellite measurements are transmitted from a roving receiver at regular 1 second intervals (or as data becomes available)
Data is received by cloud service
Does data stem from a reference receiver?
Yes
Data is stored in a cloud database for later retrieval, matching, and usage
No
Data is matched to reference data from the same corresponding time epoch and a similar geographic region
Localization procedure is carried out, producing a 3D position vector *relative* to one of the reference receivers
Relative 3D position is converted into a set of absolute 3D Earth coordinates
Resulting location coordinates are transmitted back to the roving node as soon as they become available

Fig. 7

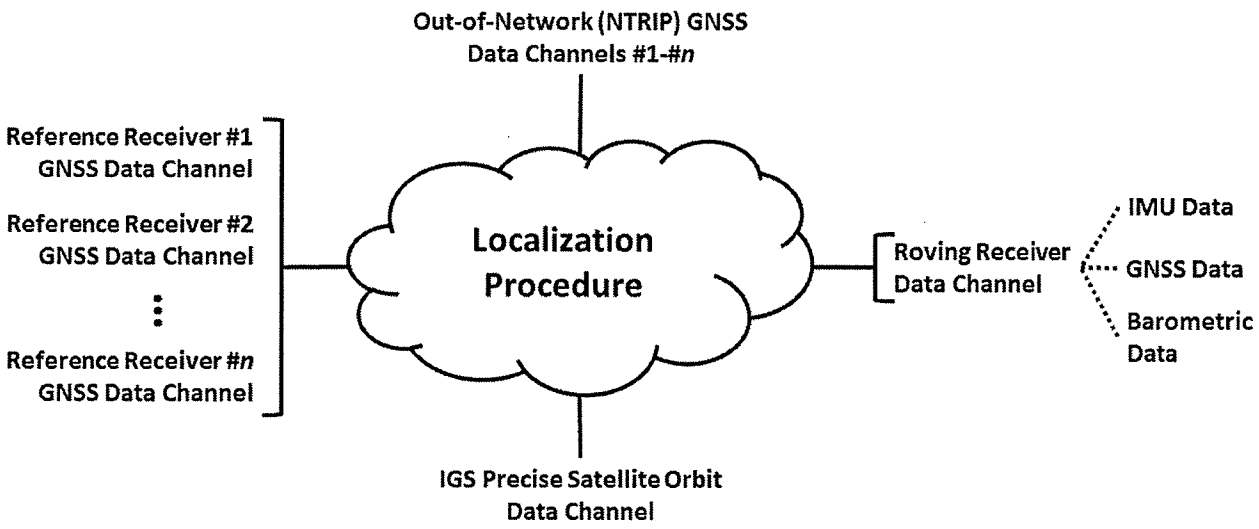

Out-of-Network (NTRIP) GNSS
Data Channels #1-#n
Reference Receiver #1
GNSS Data Channel
Reference Receiver #2
GNSS Data Channel
Reference Receiver #n
GNSS Data Channel
Localization
Procedure
Roving Receiver
Data Channel
IMU Data
GNSS Data
Barometric
Data
IGS Precise Satellite Orbit
Data Channel

Fig. 8

PTO/AIA/14 (12-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2931341-1
	Application Number	
Title of Invention	System and Methodology for a Community-Based, High-Accuracy Positioning Service Using a Network of Global Navigation Satellite System (GNSS) Receivers	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
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Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2931341-1
	Application Number	
Title of Invention	System and Methodology for a Community-Based, High-Accuracy Positioning Service Using a Network of Global Navigation Satellite System (GNSS) Receivers	

Residence Information (Select One)	◉ US Residency	○ Non US Residency	○ Active US Military Service		
City	Nashville	State/Province	TN	Country of Residence i	US

Mailing Address of Inventor:

Address 1	PO Box 121194		
Address 2			
City	Nashville	State/Province	TN
Postal Code	37212-1194	Country i	US

Inventor 4 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Akos		Ledeczi	

Residence Information (Select One)	◉ US Residency	○ Non US Residency	○ Active US Military Service		
City	Nashville	State/Province	TN	Country of Residence i	US

Mailing Address of Inventor:

Address 1	PO Box 121194		
Address 2			
City	Nashville	State/Province	TN
Postal Code	37212-1194	Country i	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	49841		
Email Address	ipdocketing@bakerdonelson.com	Add Email	Remove Email

Application Information:

Title of the Invention	System and Methodology for a Community-Based, High-Accuracy Positioning Service Using a Network of Global Navigation Satellite System (GNSS) Receivers		
Attorney Docket Number	2931341-1	Small Entity Status Claimed	☒
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	8	Suggested Figure for Publication (if any)	

Filing By Reference :

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Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	49841		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the application number blank.

Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

PTO/AIA/14 (12-13)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2931341-1
	Application Number	
Title of Invention	System and Methodology for a Community-Based, High-Accuracy Positioning Service Using a Network of Global Navigation Satellite System (GNSS) Receivers	

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(d). When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX) [i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(h)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country [i]	Filing Date (YYYY-MM-DD)	Access Code [i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Authorization to Permit Access:

☒ Authorization to Permit Access to the Instant Application by the Participating Offices

PTO/AIA/14 (12-13)
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If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

○ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
◉ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. ☒

Organization Name	Fazecast, Inc.

Mailing Address Information:

Address 1	PO Box 121194		
Address 2			
City	Nashville	**State/Province**	TN
Country [i]	US	Postal Code	37212-1194
Phone Number		Fax Number	

PTO/AIA/14 (12-13)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2931341-1
	Application Number	
Title of Invention	System and Methodology for a Community-Based, High-Accuracy Positioning Service Using a Network of Global Navigation Satellite System (GNSS) Receivers	

Email Address	

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not subsitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication . An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications

Signature	/David F. Sawrie/			Date (YYYY-MM-DD)	2014-10-23
First Name	David F.	Last Name	Sawrie	Registration Number	69950

Additional Signature may be generated within this form by selecting the Add button. Add

PTO/AIA/14 (12-13)
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This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Doc Code: **TR.PROV**
Document Description: Provisional Cover Sheet (SB16)

PTO/SB/16 (11-08)
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Provisional Application for Patent Cover Sheet

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)

Inventor(s)

Inventor 1 — Remove

Given Name	Middle Name	Family Name	City	State	Country
Will		Hedgecock	Nashville	TN	US

Inventor 2 — Remove

Given Name	Middle Name	Family Name	City	State	Country
Miklos		Maroti	Szeged		HU

Inventor 3 — Remove

Given Name	Middle Name	Family Name	City	State	Country
Peter		Volgyesi	Nashville	TN	US

Inventor 4 — Remove

Given Name	Middle Name	Family Name	City	State	Country
Akos		Ledeczi	Nashville	TN	US

All Inventors Must Be Listed – Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Title of Invention	System and Methodology for Community-Based, High-Accuracy Positioning Service Using a Network of Global Navigation Satellite System (GNSS) Receivers
Attorney Docket Number (if applicable)	2931341-000001

Correspondence Address

Direct all correspondence to (select one):

◉ The address corresponding to Customer Number	○ Firm or Individual Name
Customer Number	49841

PTO/SB/16 (11-08)
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U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.
(●) No.
( ) Yes, the invention was made by an agency of the United States Government. The U.S. Government agency name is:
( ) Yes, the invention was under a contract with an agency of the United States Government. The name of the U.S. Government agency and Government contract number are:

Doc Code: **TR.PROV**
Document Description: Provisional Cover Sheet (SB16)

PTO/SB/16 (11-08)
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U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number

Entity Status
Applicant asserts small entity status under 37 CFR 1.27 or applicant certifies micro entity status under 37 CFR 1.29

- (●) Applicant asserts small entity status under 37 CFR 1.27
- ( ) Applicant certifies micro entity status under 37 CFR 1.29. Applicant must attach form PTO/SB/15A or B or equivalent.
- ( ) No

Warning

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

Signature

Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/David F. Sawrie/			Date (YYYY-MM-DD)	2014-10-23
First Name	David F.	Last Name	Sawrie	Registration Number (If appropriate)	69950

This collection of information is required by 37 CFR 1.51. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **This form can only be used when in conjunction with EFS-Web. If this form is mailed to the USPTO, it may cause delays in handling the provisional application.**

Privacy Act Statement

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The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, t o a n other federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	SYSTEM AND METHODOLOGY FOR A COMMUNITY-BASED, HIGH-ACCURACY POSITIONING SERVICE USING A NETWORK OF GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) RECEIVERS
First Named Inventor/Applicant Name:	Will Hedgecock
Filer:	Peter L. Brewer/David Sawrie
Attorney Docket Number:	2931341-000001

Filed as Small Entity

Provisional Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Provisional Application Filing Fee	2005	1	130	130
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**130**

Electronic Acknowledgement Receipt

EFS ID:	20504509
Application Number:	62067917
International Application Number:	
Confirmation Number:	7397
Title of Invention:	SYSTEM AND METHODOLOGY FOR A COMMUNITY-BASED, HIGH-ACCURACY POSITIONING SERVICE USING A NETWORK OF GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) RECEIVERS
First Named Inventor/Applicant Name:	Will Hedgecock
Customer Number:	49841
Filer:	Peter L. Brewer/David Sawrie
Filer Authorized By:	Peter L. Brewer
Attorney Docket Number:	2931341-000001
Receipt Date:	23-OCT-2014
Filing Date:	
Time Stamp:	19:45:31
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$130
RAM confirmation Number	5395
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1		fazecast_provisional_23OCT2014.pdf	1286568 4768b569852bf4f8ff5bcfbad696dfc21b681ce7	yes	25

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Specification	1	15
	Claims	16	16
	Abstract	17	17
	Drawings-only black and white line drawings	18	25

Warnings:

Information:

2	Application Data Sheet	fazecast_provisional_ads_23OCT2014.pdf	1560972 a2aee227be2ce3a95a50584bc756140af21e8126	no	8

Warnings:

Information:

3	Provisional Cover Sheet (SB16)	fazecast_provisional_cover_sheet_23OCT2014.pdf	1476990 58e8284e0122021ffca234d53648f2e6dda20146	no	4

Warnings:

Information:

4	Fee Worksheet (SB06)	fee-info.pdf	30149 b4e20c52eec02837af1032af07dbf0028306485c	no	2

Warnings:

Information:

Total Files Size (in bytes):	4354679

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.