METHOD OF LOCATION USING SIGNALS OF UNKNOWN ORIGIN

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ABSTRACT

The present invention encompasses a method of location comprising: using a plurality of signal transceivers to receive one or more multiple frequency input signals, wherein said multiple frequency input signals are of unknown origin, and said signal transceivers are of known physical location, finding a difference in time of the reception of the signals between each of the signal transceivers, using the difference in time of reception to locate the origin of the signals, utilizing the signals locate a signal transceiver of unknown location.

BACKGROUND OF INVENTION

1.Field of invention:

This invention relates generally to global positioning systems (GPS) and, in particular, GPS systems used for emergency location of cellular handsets.

2. Description of related art

Various methods have been put forth in order to address the need for an emergency cellular location system. One method utilizes a number of cell transmission towers to locate a cell phone user by standard triangulation methods. This method is limited due to the low level of handset power in that it is unlikely that three or more towers will receive the signal needed for triangulation. Another method utilizes the GPS system, whereby a GPS transceiver is located in the cell handset. Like the cell-tower system, this method is limited because of the lack of transmitted power, but also due to the distance of the satellite mounted transmitters from the handset transceiver.

SUMMARY OF INVENTION

A unique method is introduced herein, whereby local signals are utilized to locate an unknown-location signal transceiver. In this method, three or more known-location signal transceivers are used to locate one or more unknown-location transmitters of signals of greater than zero bandwidth by way of delay differentiation. A combination of three or more signal transmitters comprising one or more unknown-location transmitters are then utilized to locate the unknown-location signal transceiver.

In one embodiment, three or more standard television and radio signals are located using three or more cell sites and, with timing referenced to the signals received by the cell sites, a cellular handset is located. In another embodiment, the delay from one or more cell sites to the hand set is utilized, along with one or more unknown-location transceiver to locate the cellular handset. A third embodiment utilizes mobile transmitters, such as emergency or police band radios to locate and utilize for handset location. A fourth embodiment utilizes other cellular handsets in order to locate a cellular handset. The preferred embodiment employs all four of these means to locate a cellular handset.

One method introduced herein comprises 1) measuring the difference of delay from one or more unknown-location signal transmitters to three or more known-location signal transceivers. 2) utilizing said delay difference measurements to locate the one or more unknown-location signal transmitters. 3) locating an unknown-location signal transceiver by way of a combination of three or more signal transmitters comprising one or more unknown-location transmitter.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows the constellation of possible locations using known-location signal transceivers AB, AC, and BC for various differences in time with respect to the transmission time from a first known-location signal transceiver to a second known-location signal transceiver.

Figure 2 shows the location of a specific point (x) using any two of the vector sets.

Figure 3 shows a point (x) located within three points A, B, and C.

Figure 4 shows a point (x) located outside three points A, B, and C.

Figure 5 shows three cell towers(T1,T2,T3) and three cellular handsets (H1,H2,H3).

Figure 6 shows another method wherein a first handset receives signals from two towers and a second handset receives a signal from a third tower.

Figure 7 shows multiple handsets used to indirectly locate a handset, whereby location of the handset to be found can be accomplished by locating other handsets within the cell, an then using the other handsets as known-location transmitters.

FULL DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the first embodiment, a remote processing station sends a request to three or more known-location signal transceivers to send return signals in order to measure the delay from each known-location signal transceiver to the processing station. Each known-location signal transceiver receives signals from three or more unknown-location transmitters and sends the signals from the unknown-location transmitters to the remote processing station. The processing station then measures the difference in time between the signals received by the known-location signal transceivers from each unknown-location transmitter by subtracting the respective transmission line delays. The net delay differences from each unknown-location transmitter to each of the known-location signal transceivers are used to locate each unknown-location transmitter at a point in space.

Figure 1 shows the constellation of possible locations using known-location signal transceivers AB, AC, and BC for various differences in time with respect to the transmission time from a first known-location signal transceiver to a second known-location signal transceiver. As an example, the constellation labeled .8 is represents a set of points where the transmission time from any point on the arc to point A is equal to the transmission time to point B plus 80 % of the transmission time from point A to point B.

Figure 2 shows the location of a specific point (x) using any two of the vector sets. Using vector sets AB and AC, the constellations .4 and .8 cross to locate point (x). Using vector sets AB and BC, the constellations .4 and -.2 cross to locate point (x). Using vector sets AC and BC, the constellations .8 and -.4 cross to locate point (x).

Figure 3 shows a point (x) located within three points A, B, and C. A mathematical representation follows:

$$(AB)^2 = (Z_a)^2 + (Z_a - b)^2 - 2(Z_a)(Z_a - b)\cos(\phi_{AB})$$
$$(AC)^2 = (Z_a)^2 + (Z_a - c)^2 - 2(Z_a)(Z_a - c)\cos(\phi_{AC})$$
$$(BC)^2 = (Z_a - b)^2 + (Z_a - c)^2 - 2(Z_a - b)(Z_a - c)\cos(2\pi - \phi_{AB} - \phi_{AC})$$

Where Z_a represents the delay from (x) to A, and b and c represent the difference in delay from (x) to B and C with respect to the distance from (x) to A.

Z_a, ϕ_{AB}, and ϕ_{AC} are unknowns, they can be found mathematically or by iteration with the three independent equations shown above. With the three variables known, the x and y coordinates of the transmitter (x) can be found.

Figure 4 shows a point (x) located outside three points A, B, and C. A mathematical representation follows:

$$(AB)^2 = (Z_a)^2 + (Z_a - b)^2 - 2(Z_a)(Z_a - b)\cos(\phi_1)$$
$$(AC)^2 = (Z_a)^2 + (Z_a - c)^2 - 2(AC)(Z_a - c)\cos(\phi_2)$$
$$(BC)^2 = (Z_a - b)^2 + (Z_a - c)^2 - 2(Z_a - b)(Z_a - c)\cos(\phi_1 + \phi_2)$$

Again, Z_a represents the delay from (x) to A, and b and c represent the difference in delay from (x) to B and C with respect to the distance from (x) to A.

Z_a, ϕ_1, and ϕ_2 are unknowns, they can be found mathematically or by iteration with the three independent equations shown above. With the three variables known, the x and y coordinates of the transmitter (x) can be found.

The remote processing station sends a request to an unknown-location signal transceiver, either directly or by way of one of the known-location signal transceivers, to send a return signal in order to measure the delay from the unknown-location signal transceiver to the processing station.

The unknown-location signal transceiver receives the signals from the three or more unknown-location transmitters and sends the signals from the unknown-location transmitters to the remote processing station.

The processing station then measures the delay from each of the three or more unknown-location signal transmitters to the processing station, by way of the unknown-location signal transceiver and finds the delay from the unknown-location signal transmitters to the unknown-location signal transceiver by comparing the signal received by the unknown-location signal transceiver and the signal received by any one of the three or more known-location signal transceivers and by subtracting the delay from the unknown-location signal transceiver to the processing station.

With each of the points of transmission known, the signal delay from each point of transmission to the unknown-location signal transceiver known, standard triangulation methods can be used to find the unknown-location signal transceiver.

In other words, the location of the unknown-location signal transceiver is calculated by measuring the difference of reception in time of three or more independent signals to each of the known-location signal transceivers and to the unknown-location signal transceiver.

In a second embodiment, the location of the unknown-location transmitters is as described in the first embodiment. A second method of location of the unknown-location transceiver is described herein.

In the second embodiment, the remote processing station sends a request to an unknown-location signal transceiver, by way of one or more of the known-location signal transceivers, to send a return signal in order to measure the delay from the unknown-location signal transceiver to said one or more of the known-location signal transceivers in order to measure the delay from the unknown-location signal transceiver to the one or more of the known-location signal transceivers.

The unknown-location signal transceiver receives the signals from one or more unknown-location transmitters and sends part or all of the signals from the unknown-location transmitters to the remote processing station, by way of the one or more of the known-location signal transceivers.

The processing station then measures the delay from each of the one or more unknown-location signal transmitters to the processing station, by way of the unknown-location signal transceiver and finds the delay from the unknown-location signal transmitters to the unknown-location signal transceiver by comparing the signal received by the unknown-location signal transceiver and the signal received by any one of the three or more known-location signal transceivers and by subtracting the delay from the unknown-location signal transceiver to the processing station.

With each of the points of transmission known, the signal delay from each point of transmission to the unknown-location signal transceiver known, and the delay from the unknown-location signal transceiver to the one or more of the known-location signal transceivers known, any combination of the one or more of the known-location signal transceivers and the one or more unknown-location signal transmitters is utilized in standard triangulation methods to find the unknown-location signal transceiver.

In a third embodiment, mobile transmitters, such as police band radios are located using a similar method as in the first embodiment. In this method, however, the reception of signals must be time marked as they arrive at the processing station since the location of the transmitter is constantly changing. Location of the unknown-location transceiver is as with the first or second method introduced herein.

In a fourth embodiment, three known-location transceivers, in combination with other unknown-location transceivers are used to locate the first unknown-location transceiver. Because cellular hand sets, regardless of whether or not in use, are in communication with nearby cell sites, and hand sets within the same cell communicate at different frequencies, each handset in the cell can be used as a repeater.

Figure 5 shows three cell towers(T1,T2,T3) and three cellular handsets (H1,H2,H3). The processing station pings each handset in order to find the delay between the handset and the corresponding tower and the delay from each tower to the processing station. If an adjacent handset receives the return signal from its neighboring handset, the delay between the two handsets is used for location. In other words, adjacent handsets are used as repeaters.

As an example, if H3 receives the return signal from H2, the delay can be found between H2 and H3 providing that the communication between each handset and its corresponding tower are at different frequencies, because the processor is aware of when the signal was sent to H2 and the delays between the handsets and corresponding towers are known. Two possibilities for location of both H2 and H3 are indicated. If H1 is able to receive the return signal from H2 or H3, triangulation to H2 and H3 is possible.

Figure 6 shows another method wherein a first handset receives signals from two towers and a second handset receives a signal from a third tower. Pinging of the first handset by the corresponding towers reveals two possibilities for location, communication between handsets reveals the true location of both handsets.

Figure 7 shows multiple handsets used to indirectly locate a handset, whereby location of the handset to be found can be accomplished by locating other handsets within the cell, an then using the other handsets as known-location transmitters. Although H5 has no communication with H1 and H2, communication with H3 and H4 is possible. With the delays between T1 and H1, T2 and H2, H1 and H4, H3and H5, T2 and H3, T2 and H4 known, H1 through H4 can be located and used to find H5.

In the preferred embodiment, the four methods described above are utilized to locate a cell handset. In this embodiment, the remote processor pings three or more cell sites in order to find the delay between the sites and the processing station. Transceivers attached to the cell sites scan the area in order to find local transmitters and other handsets. The remote processor then locates any transmitters by way of the method described in method one herein. The remote processor then pings the cell handset to be located in order to find the delay from the handset to any cell sites in which the handset is communicating. The cell handset, which contains a similar transceiver as the cell sites, along with one or more cell sites, is instructed to receive one or more of the transmitters found so that an approximation can be made regarding the location of the handset. Once an approximate location is found, The remote processor then instructs cell sites near the transmitters to accurately locate the located transmitters. The processor also makes an evaluation of transmitter location accuracy based on the distance from the cell sites used to locate the transmitter to the corresponding transmitter and based on how optimum the cell sites are located around the transmitter. Based on this accuracy, the remote processor selects the transmitters which will provide the highest accuracy of handset location. If this selection comprises a nearby cell handset, the nearby handset and any cell towers in communication with the nearby handset are instructed to find the delay from each of the towers in communication with the nearby handset and to use the nearby handset as a signal repeater. If a mobile transmitter is to be utilized, the processor time stamps the delay information to account for a varying location.

Any combination of location methods described herein are utilized to locate the cell handset. The process continuously repeats to find new, more optimum transmitters. As an example, an emergency vehicle radio would likely become a transmitter as it approaches the handset.