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OFFICE OF TECHNOLOGY TRANSFER AND ENTERPRISE DEVELOPMENT

Highly Accurate Radio Chip Localization Technology

Summary

This technology uses conventional hardware in combination with a patented algorithm using radio signals to create a technology that locates tangible objects to within three centimeters.

Description

Most wireless sensor networks applications (WSN) in existence today require, in order to operate, knowledge of the location of individual nodes that form the network. Robust sensor localization is still a largely unresolved problem. While there are many approaches that seek to solve the problem, they all have significant weaknesses that limit their applicability in the real world.

GPS is a widely used method. It is, however, relatively expensive and not accurate enough for many applications. Technologies like acoustic ranging, which are more accurate, have limited range. They require an actuator/detector pair that adds to the cost and size of the platform.

For applications that require stealth, ultrasound is often the only acoustic option. Ultrasonic methods, however, have an even more limited range, as well as directionality constraints. Methods that utilize radio signals typically rely on the received signal strength that is relatively accurate over short distances (with extensive calibration), but imprecise beyond a few meters.

This technology, developed at Vanderbilt University's Institute for Software Integrated Systems, uses radio interferometry and attains, simultaneously, a high degree of accuracy, considerably longer range and lower cost than other technologies.

Traditional radio interferometry has many applications in physics, geodesy and astronomy. The method is based on two directional antennas measuring the radio signal from a single source and performing cross correlation. The resultant interference signal can be further analyzed to create radio images of distant celestial objects, determine the relative location of two receivers very precisely or conversely, determine the location of a radio source when the location of the two receivers are known.

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However, that technique using a radio interferometer is not directly applicable to WSNs because it requires very expensive equipment. The novel idea behind the proposed technology is that it utilizes two simple transmitters to create the interference signal directly. If the frequencies of the two emitters are almost the same, the composite signal will have a low frequency envelope that can be measured by modestly priced and simple hardware readily available on a WSN node.

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Using this signal to deduce information on the positions of the two transmitters and the receiver directly would require tight synchronization of the nodes involved with considerable hardware support. Instead, we use the relative phase offset of the signal at two receivers, which is a function of the relative positions of the four nodes involved and the carrier frequency. By making multiple measurements in a network that contains a minimum of seven nodes, it is possible to reconstruct the relative location of the nodes in three dimensions. Our prototype implementation runs on the XBow MICA2 platform and yields an average localization error as small as three centimeters and a range of up to 160 meters. These remarkable numbers present an order of magnitude improvement in both range and accuracy over the currently available technology. Improvements that will further reduce the localization error and increase the range are now being developed.

In addition to wireless sensor networks, this technique is equally relevant to any application that requires highly accurate, three dimensional positioning. Devices capable of performing the localization measurements are inexpensive, and the computations can be carried out on any computer.

Potential Market Size

Vanderbilt University has considered a number of potential applications for the technology, including structural engineering, sports, inventory management and robotics. Obviously, any positioning applications requiring a high degree of accuracy, greater physical range than current technologies offer and low cost would be logical candidates.

Additional Research

This technology is less accurate when used indoors or in environments where radio signals may echo. A recent test at a large, 300,000 square foot warehouse facility operated by Osburn Hessey Logistics in Smyrna, Tennessee found that this technology was accurate to within ±1 meter. Similar limitations have been identified at other indoor locations and locations where there are obstructions.

Intellectual Property Status

U.S. Patent number 7,558,583.

Demonstration Project with Oak Ridge

In 2006, Vanderbilt collaborated with the Oak Ridge National Laboratory to showcase this technology and a sophisticated radiation detection technology from Oak Ridge. The collaboration was conducted during a “Dirty Bomb Detection and Localization” demonstration at the Vanderbilt stadium.

The two technologies were used to track a plain clothes security guard who circulated through the stadium with a cell phone-integrated radiation detector. This individual was tracked using the Vanderbilt technology both on a television monitor and on a Google Earth™ user-interface.

More information about this demonstration project and news links about the demonstration may be found at http://www.isis.vanderbilt.edu/projects%5Crips/.

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