Indoor Localization using Broadcasting FM signals TDOA triangulation

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The use of GPS satellites for global positioning using TOA triangulation has revolutionize the world with precision location and timing. The GPS use synchronized precision atomic clocks among all satellites, and ground receiver synchronized with GPS via additional time variable to determine the time of transmission and arrival. Even though GPS is globally accepted as a standard outdoor navigation means, the signal strength is unable to penetrate indoors for indoor localization purpose.

Previous to GPS, LORAN and OMEGA systems were used by military widely in WWII based on TDOA triangulation. The advantage of TDOA versus TOA is that the precision synchronized clock is not necessary between the transmitter and receiver. However, the ground based LORAN and OMEGA systems using HF or VHF waves for time difference of arrival going through the atmosphere has various interference, multi-path and weather related delays; which cause the location precision unacceptable in modern applications.

Various indoor localization systems have been proposed in the past few years. The proposed systems either require expensive infrastructure such as UWB or ultrasounds, limited coverage systems such as WiFi, Bluetooth, RFID or DECT. Many authors recently proposed to utilize free FM broadcasting signals or inexpensive self generated local FM transmitters. FM represents a popular and well-established technology of broadcasting since 1960 around the world. FM signal modulation in the VHF band is more robust with uniform signal strength; less susceptible to human presence, multi-path and fading; and with very good indoor penetration as experienced by indoor listening of FM versus AM broadcasting. Majority of proposed FM systems for indoor localization are using FM signal RSSI or so called fingerprinting for triangulation. The disadvantage of using RSSI is that the FM signal strength may weaken by different blockages from three triangular directions of FM transmitters. It will cause position error.

Even though FM signal RSSI can be weakened by blockage, but the phase information of FM signal is not changed by blockage. Therefore, we patented a TDOA system of triangulation using FM signal phase in 2011 (ref. 11,12). In particular we propose to use the broadcasting FM stereo demodulated 19 KHz pilot tone phase difference for TDOA triangulation.

Using three FM stations with synchronized pilot tone phase differences will generate two pairs of hyperbolic curves in 2-dimensional space. The intersection of selected two hyperbolic curves would determine the location of mobile station position.

Due to unknown local FM broadcasting stations and signal quality of Vienna city and environment, our experiment will bring with us three (3) low power FM stereo transmitters (LPFM) transmitter for the contest. This does not exclude us from using public FM broadcasting stations for indoor localization in the future.

For best result of location precision, it is desired to get the best DOP (dilution of precision) similar to GPS. The three FM transmitters are best to be located as right triangle to achieve the best triangulation. For commercial FM broadcast stations, it is desired to pick three FM station located at triangular positions as well. For 3-D

positioning, it is entire possible if we can hang an additional transmitter attached to the ceiling of the contest facility to do 4 FM stations triangulation. Since we do not know the contest facility ceiling height in Vienna and means to attach the transmitter to the ceiling, we are not prepare in this stage to do the 3-D positioning at this time.

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