Indoor Wireless Localization to Achieve 0.3 Meters' Accuracy

----Exploiting Distributed Space time Codes

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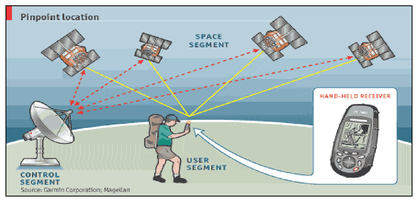
Why Indoor Wireless localization?



- Navigation: GPS fails in parking garages
- Tracking: monitoring movements of people and objects
- Routing: helping improving wireless network speed

Challenges for Indoor Localization

- **Requires much higher accuracy than outdoor case!**

  10 meters (outdoor) ➡ fraction of 1 meter (indoor)

- **Indoor environments can be complex !**

  No line-of-sight ➡ GPS becomes helpless

  Walls and obstacles in room ➡ Multipath fading

- **System cost control !**

  1 nano second discrepancy ➡ 3.3 meters error

  But high-precision atomic clocks are expensive

  ➡ Only available to reference nodes, sensors have none

Existing Approaches

Sensors transmit one by one … reference nodes listen and determine (relative) distances and positions via, for example, Time Difference Of Arrival (TDOA)…

Lots of sensors ➡ takes a long time to localize them !

Our Approach

Reference nodes transmit … all sensors listen and determine their (relative) distances and positions via (TDOA)…

Sensors can simultaneously determine their own positions ➡ considerably expedite process when lots of sensors!

But sensors are not equipped with high-precision clocks, and signals are randomly faded (difficult to catch)…

☺ **Exploit the power of distributed space-time codes!**

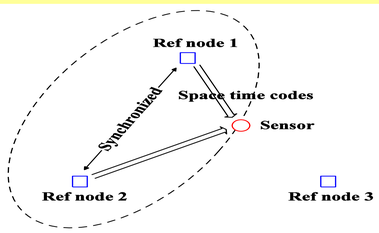
Novel Solution: Distributed Space-Time Codes (DSTC)

• DSTC: a powerful technology for combating fading and improving transmission reliability & throughput.

• Here we exploit DSTC in combination with new synchronization techniques to achieve localization !

☺ Exploit antennas from different reference nodes ➔ virtual antenna array ☺ distributed reference nodes transmit simultaneously ➔ distributed space-time codes

☺ All sensors simultaneously determine TDOA ➔ by performing accurate synchronization of DSTC

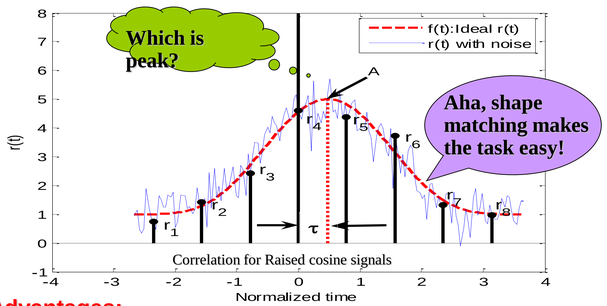


Smart Way of Synchronization: Maximum Likelihood

Traditional TDOA – correlation estimator

- Sync point is determined by peak of correlation
- Accuracy intrinsically limited by over-sample rate
- Sensitive to noise, fading and other channel impairments

We propose: to match entire shape of correlation func



Advantages:

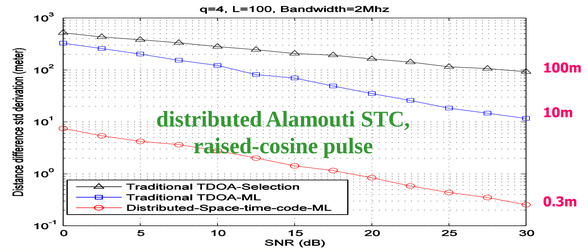
☺ All values (instead of only peak value) are now fully utilized.

☺ Robust to noise etc.

☺ Precision un-constrained to over-sample rate

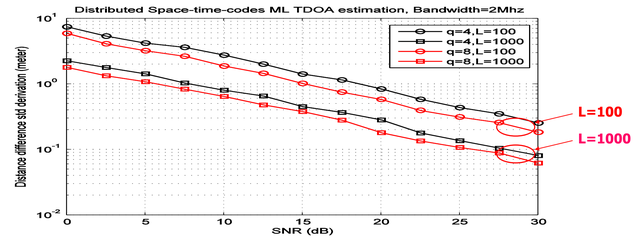
Performance Evaluation through Simulations:

Our solution compared with conventional techniques in GPS



- Traditional GPS: 100 meters' accuracy in NLOS condition (due to small bandwidth and limited over-sampling rate)
- ML estimation for traditional GPS: 10 meters' avg error at 30 dB
- **ML estimation for DSTC: 0.3meters' avg error at 30 dB**

Comparing different system parameters



Increasing over-sample rate and length of signal sequence both improves localization accuracy.

(Increasing sequence length costs no change to hardware)

Contributions

Developed a novel indoor localization technology that is efficient, highly accurate and robust to noise and fading!

Distributed space-time codes through virtual antenna array:

* Effectively combats multi-path fading, increases localization accuracy
* Significantly enlarges localization range, because reference nodes can afford much higher transmit power than sensor
* Drastically reduces localization time when there are many sensors

New estimation algorithm:

Maximum-likelihood TDOA estimation derived

* fully harness correlation functions, robust and accurate

Excellent simulation results:

Localization error as small as 0.3 meters