Collaborative Navigation using GPS Distributed Aperture Positioning

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GPS Issues to be Overcome

- GPS signals may be attenuated when operating under foliage, in an urban canyon, or inside a building to the extent that they cannot be detected by a conventional GPS receiver.
- GPS signals can be denied when in close proximity to a GPS jammer or interference source.
- The GPS signals can be corrupted with multipath when operating in urban canyons.
- GPS navigation is not possible without sufficient satellites to provide good geometry (PDOP).
GPS Distributed Aperture Solution

- Combines individual GPS observations and intra-network ranges from a sparse network
- Calculates ensemble network location solution even when no locations can be “anchor points”
Use of common clock allows GPS time-stamping of SRW Tx signal frames for 1-way TOA ranging
Software GPS Solution enables precise timing on

GNSSµSDR system architecture

GPS-Lite Snapshot Solution

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GPS Snapshot Timing Testing

Timing Test-Bed captured snapshots from two different receivers using a common timemark.

Time Differences were accurate to within 0.44m or 1.5 nsec (1-sigma)

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GDAP Simulation Tool

- Calculates ray paths from transmitters to receivers
  - TOA between units
  - Jammers
  - SoA
- Calculates ray path passing through buildings
- Models signal loss from RF propagation and dB/meter propagation loss in Building
GDAP 3D Models

- GDAP simulates urban environment using Google 3D model
- Building a GDAP Google Earth 3D Model:
  - 3D Warehouse includes downloadable city models
  - Sketch-Up exports into 3D model file
  - Matlab reads as shape file for GDAP simulation
  - GDAP user paths entered in using Google Earth
NY 3-D Model
New York Satellite Visibility
NY Simulation Example
NY Performance

- For each time step, GDAP on left, GPS only on right
- Compare GDAP green/blue with GPS green
- No jammers

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Denver 3-D Model
Denver GPS Visibility

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Denver: no jammers, step 2

Receiver status, Timestep 2
Other Ranging Signal (SoA)

- GPS Jammers: Time Difference of Arrival (TDOA) + Jammer Location (LOC)
- Television: TDOA + TV transmitter location database
JLOC Processing Run
JLOC Processing Run with additional time steps
Denver with Jammer and TV SOA, step 3
Denver Performance

• Compare GDAP (Green/Blue) with GPS only (Green)
GDAP Test Bed

GPS Satellite

Digital TV

Digital TV Signals (300 to 750 MHz)

Commercial GPS

NAVSYS L1 DAE

SRW 0.5CC Operating at 900MHz

Coherent Logix hxHADS Modules Running SRW, GDAP TOA and TDOA Waveforms

Ethernet

GDAP Workstation

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Conclusion

- GPS Distributed Aperture Positioning provides robust collaborative positioning in an urban environment where GPS satellite visibility is occluded.
- GDAP leverages GPS + RF Ranging Network assistance to allow positioning of users in an environment where GPS is completely obstructed or denied.
- GDAP urban simulation tool can be used to generate simulated scenarios in a complicated urban environment.
- Lab and field testing planned with GDAP test bed under US Army contract with DARPA SBIR funding.
Back-Up
HyperX

Simplification of System Partition and Implementation

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GDAP System Architecture