

18-452/18-750
Wireless Networks and Applications
Survey 7:
Localization

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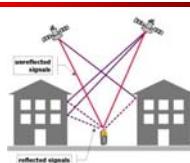
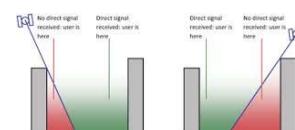
Outline

- Review of last lecture
 - » GPS
 - » CAESAR
- Importance of Localization
- More Hybrid Systems
 - » SAR
 - » UnLoc

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GPS:

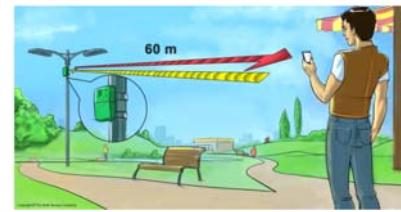
- **Outdoors:**
 - It provides good accuracy (2–3 m).
 - It has become almost ubiquitous in today's society
- **Indoors/Concrete Jungle:**
 - High attenuation of the RF signals from the GPS satellites through buildings.
 - Shadowing and multi-path disrupt signals resulting in low resolution.

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How do we deal with indoors?

- Current technologies used to solve indoor location:
 - Ultrasonic
 - IR
 - UWB
 - WiFi
 - Bluetooth
 - Non-wireless approaches



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Time-based location estimation

- TOF defined as the time that the signal takes to travel from Node A to Node B
 - $T_{\text{flight}} = T_{\text{arrival}} - T_{\text{transmit}}$ (ex. GPS)
- More often, Round trip time is used than single direction time of flight, thus:
 - $T_{\text{round}} = T_{\text{arrival}} - T_{\text{transmit}}$ (At transmitter)
 - $T_{\text{flight}} = (T_{\text{round}} - T_{\text{processing}})(1/2)$ (ex. CAESAR)
 - Distance = $c \cdot T_{\text{flight}}$

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Et tu Brute?

- CAESAR:
 - Average errors of less than 1 m are obtained in 8 links out of 10.
 - A lower accuracy is obtained in links with severe multipath obstruction.
 - The error drops below 2 m after fewer than 25 samples in 9 links out of 10.
 - It is stable across different frame rates at the L-STA.
 - WLAN interference has a limit impact on the estimate, when 3 other stations send a high traffic rate.
 - It can track the distance to a WLAN smartphone at pedestrian speeds both outdoors and indoors.

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Why the need for Hybrid?

- Unlike, outdoors, Indoor localization usually needs higher level granularity.
 - 2-3m would be the same street outdoors, but different aisle/store indoors
- Achievable with wifi alone, but requires super high density of nodes and requires exact calibration
- Non-wifi wireless solutions exist at the cost of new infrastructure

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Outline

- Review of last lecture
 - » GPS
 - » CAESAR
- Hybrid Options
 - » Ubicarse
 - » Antenna Array
 - » SAR
 - » UnLoc
 - » Dead Reckoning
 - » Fingerprinting on Sensor data

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Antenna Array

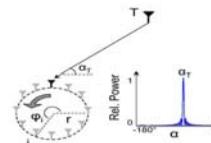
- Antenna Arrays can be used to detect with great precision the physical direction of the transmitter
- Not suitable for phone
 - As show ->



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Synthetic Aperture Radar (SAR)

- SAR is a technique of using a single antenna to emulate an antenna array.
- Traditional SAR techniques are used to get millimeter accuracy.
- requires precise knowledge of how the antenna is located in space



$$P(\alpha) = \left| \frac{1}{n} \sum_{i=1}^n h_i e^{\frac{j2\pi}{\lambda} r_i \cos(\alpha - \phi_i)} \right|^2$$

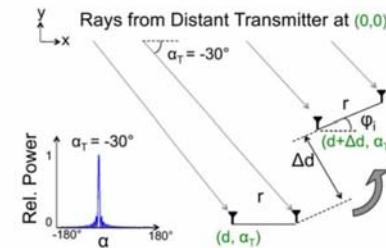
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UbiCarse: SAR for a phablet

- Translation Independence:
 - Traditional SAR requires mm accuracy for position of antenna. Easy on radar systems. Impossible on phones
 - UbiCarse uses a two antenna device to detect and compute the direction of source
- Assumptions:
 - during SAR computation, the source is at a far distance compared to the movement of the tablet.

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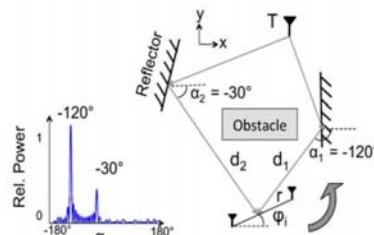
UbiCarse: Does it work?



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Ubicarse: Multipath

- median error of 39 cm in full three dimensional space.



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Unsupervised localization?

- All of the previous solutions require some form of war-driving.
- Can we do it autonomously?

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Unloc: Fingerprinting landmarks

- Fingerprinting Sensor data in conjunction with Dead-reckoning to localize users
- Landmark based localization generates broad estimations based on smartphone sensor data.
- Several modern infrastructure exhibit unique magnetic/RF/accelerometer reading
- Issues:
 - Drift error from Accelerometer
 - Fingerprinting is susceptible to small changes in environment

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Unloc: Landmarks

- Seed Landmarks (SLM):**
 - Unloc relies on pre-existing data on a building's layout to identify landmarks that are known to exhibit predictable user interaction:
 - Stairs (pressure/accelerometer data)
 - Elevators (magnetometer/accelerometer)
 - Entrances (significant drop in GPS signal)
 - Escalators (magnetometer/accelerometer)
- Organic Landmarks (OLM):**
 - Several locations in an indoor system will exhibit unique ambient signatures (fingerprinting).
 - Clusters user's sensor data along with dead-reckoning to estimate location of organic landmark.
 - Wifi strength,

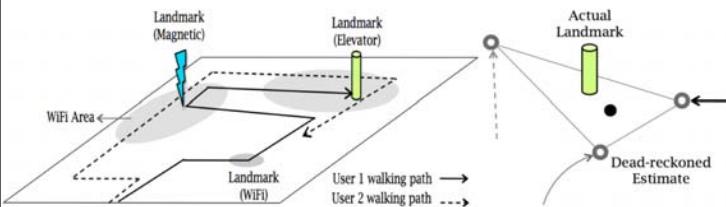
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Dead-reckoning

- Using the accelerometer readings of the mobile phone, count steps a person has walked, and therefrom derive the displacement of the person.
- Direction is dictated by either compass or gyroscope

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Landmark accuracy?



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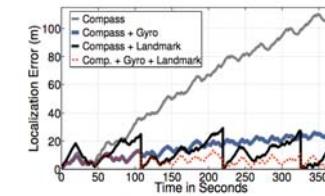
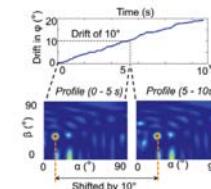
Unloc: Concerns

- Heterogeneous Hardware – will the clustering algorithm work on different sensor hardware?
- Phone Orientation Effect – Sensor data differ on orientation?

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But what about drift?

- IMUs are all susceptible to drift.
 - Can be estimated as a *unknown* but linear shift in direction
 - Ubicarse
 - Linear drift leads to constant shift in SAR multipath
 - Estimating shift in multipath profiles is used to actively correct for gyro drift
 - Unloc
 - Magnetic features of infrastructure lead to using the gyro
 - Landmarking zero's out error with



Questions
