DES535
Ubiquitous Computing

Dr. Pragma Kar
Assistant Professor
Department of Human-Centered Design

INDRAPRASTHA INSTITUTE *of*
INFORMATION TECHNOLOGY **DELHI**

Google Classroom Code : pcwnf5t

Location Sensing

Module IV (Part I)

References:
https://homes.cs.washington.edu/~shwetak/classes/cse590p/notes/location_preview_draft.pdf
https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=3a7cb58dec6c39d31db6c36aec6091e3149baaf6
https://graphics.stanford.edu/courses/cs428-03-spring/Papers/readings/Location/gaetano_ieee_computer01.pdf

Location Sensing : Applications

- Can you think of some
  - Simple applications
  - Derived applications

Location Sensing : Types

- Location is a position in a physical space and it can be represented in he following forms.
  - **Physical** vs **Symbolic**:
    - GPS provides physical positions. For example, our building is situated at 47°39′17″ N by 122°18′23″ W, at a 20.5-meter elevation.
    - Abstract ideas of where something is in the kitchen, next to a mailbox, on a train approaching Denver.
  - **Absolute** vs **Relative:**
    - Two GPS receivers placed at the same position will report equivalent position readings, and 47°39′17″ N by 122°18′23″ W refers to the same place regardless of GPS receiver.
    - A mountain rescue team searching for avalanche victims can use handheld computers to locate victims' avalanche transceivers. Each rescuer's device reports the victims' position relative to itself.

Location Sensing : Techniques

- **Proximity**
  - This technique uses the closeness of a device to a reference point to estimate the location of the device.
  - Either the device or the reference point can sense the proximity.
  - Can be (i) **physical** (e.g. person on pressure sensor-based floor) or (ii) **range-based** (e.g. communicating with a WiFi Access Point (AP) indicates that the device is near the AP)

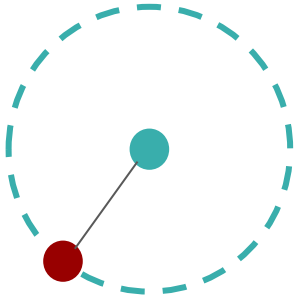
https://www.youtube.com/watch?v=4K6khbmaJVM

Location Sensing : Techniques

- **Proximity**
  - There are three general approaches to sensing proximity:
    - **Detecting physical contact.** Detecting physical contact with an object is the most basic sort of proximity sensing. Technologies for sensing physical contact include pressure sensors, touch sensors, and capacitive field detectors.
    - **Monitoring wireless cellular access points.** Monitoring when a mobile device is in range of one or more access points in a wireless cellular network is another implementation of the proximity location technique.
    - **Observing automatic ID systems.** A third implementation of the proximity location sensing technique uses automatic identification systems such as credit card point-of-sale terminals, computer login histories, landline telephone records, electronic card lock logs, and identification tags such as electronic highway E-Toll systems.

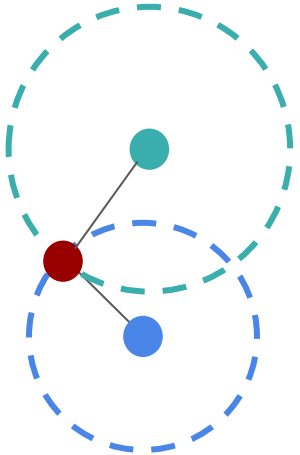
Location Sensing : Techniques

- **Trilateration**
  - ● Is the reference point with known location.
  - ● Is the device whose x,y coordinates are to be derived.
  - Calculate the distance d and draw a circle with radius d and reference in centre.
  - Estimating the distance to a single reference point yields an infinite number of possible locations of the device on the perimeter of the circle.



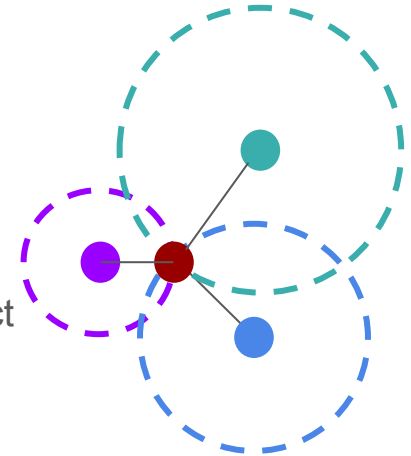
Location Sensing : Techniques

- **Trilateration**
  - Is the reference point 1 with known location.
  - Is the reference point 2 with known location.
  - Is the device whose x,y coordinates are to be derived.
  - Calculate the distances d1 and d2 and draw the circles with radius d1 and d2 and reference points 1 and 2 in centre, respectively.
  - Estimating the distance to 2 reference points yields 2 possible locations of the device on the points of overlap of the circle.



Location Sensing : Techniques

- **Trilateration**
  - Is the reference point 1 with known location.
  - Is the reference point 2 with known location.
  - Is the reference point 3 with known location.
  - Is the device whose x,y coordinates are to be derived.
  - Calculate the distances d1, d2, d3 and draw the circles with radius d1, d2, d3 and reference points 1,2 and 3 in centre, respectively.
  - **Estimating the distance** to 3 reference points yields the exact location of the device on the point of overlap of the 3 circles.

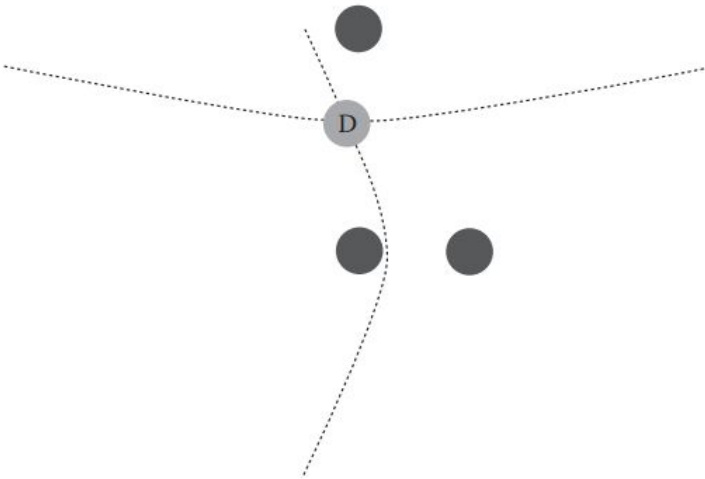


Location Sensing : Techniques

- Estimating the distance in Trilateration :
  - **Time-of-Flight** : Measuring distance from an object to some point P using time-of-flight means measuring the time it takes to travel between the object and point P at a known velocity.
  - **Attenuation** : The intensity of an emitted signal decreases as the distance from the emission source increases. The decrease relative to the original intensity is the attenuation. Given a function correlating attenuation and distance for a type of emission and the original strength of the emission, it is possible to estimate the distance from an object to some point P by measuring the strength of the emission when it reaches P.
  - **Direct** : For example, a robot can extend a probe until it touches something solid or take measurements with a tape measure.

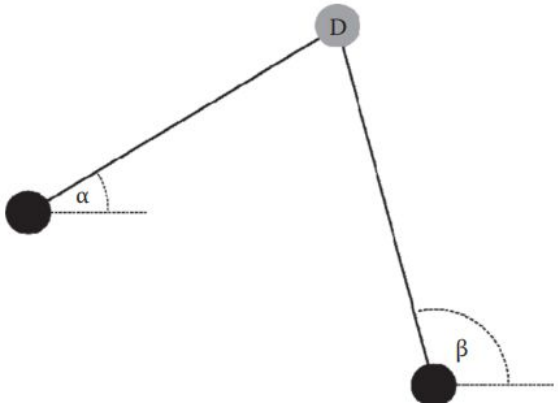
Location Sensing : Techniques

- **Hyperbolic Lateration**
  - Hyperbolic lateration uses the difference between the signal arrival times from a device to three or more reference points, instead of using the signal travel time itself. The hyperbolic lateration technique is also applicable when a device receives signals that were simultaneously transmitted by three or more reference points.
  - The signal transmitted from a device will be received at different times by reference points located at different distances from the device.
  - The difference between the signal arrival times at two reference points restricts the possible location of the device to be along a hyperbolic line, with the two reference points serving as the foci of the hyperbola.



Location Sensing : Techniques

- **(Tri)angulation**
  - Triangulation uses the angle of arrival (AOA) of signals traveling from a device to reference points to estimate the device's location.
  - Measuring the angle at which the signal arrives from the device (to a reference point restricts the position of the device along the line that passes through the reference point along the AOA.
  - Measuring angles from two reference points results in two lines that uniquely define the device's location at the point of intersection. Thus, it is enough to have angle measurements from only two reference points to determine the location of the device in two dimensions; in practice, however, more than two reference points are used to reduce angle measurement errors.



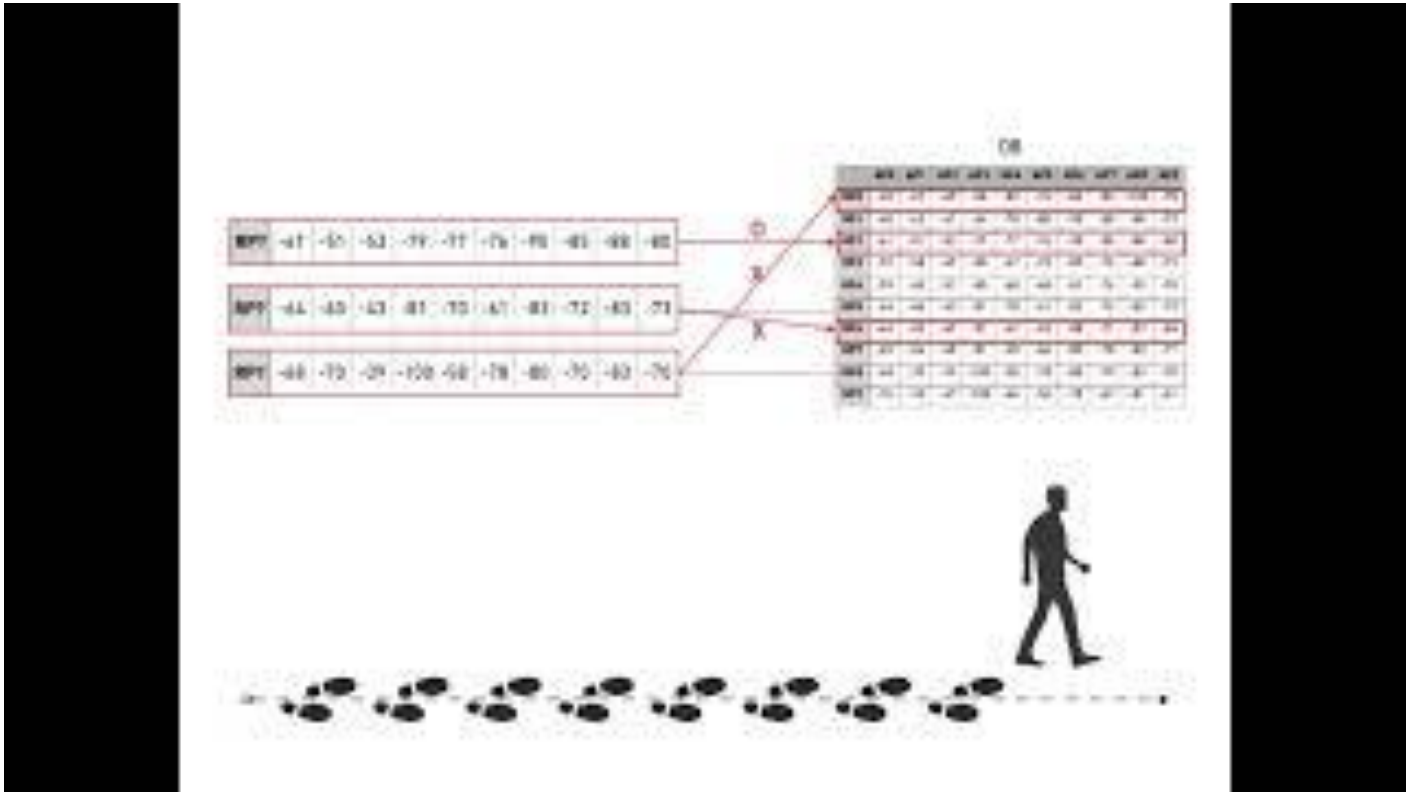
Location Sensing : Techniques

- **Fingerprinting**
  - Fingerprinting is a location technology that uses pattern matching techniques to estimate the location of a device.
  - RF fingerprinting relies on two properties of radio signals: **temporal stability** (stability of a radio signal from a radio source at any given location over time) and **spatial variability** (variability of the radio signal from the same radio source at two different locations).
  - The accuracy of a fingerprinting system is closely tied to the degree of spatial variability of the signal.
  - Fingerprinting relies on a training phase to build a radio map of the target environment before it can be used for location determination. During the training phase, a device moves through the environment, taking measurements of the strength of signals emanating from a group of radio sources.

SSID (Name)	BSSID (MAC Address)	Signal Strength (RSSI)
linksys	00:0F:66:2A:61:00	18
starbucks	00:0F:C8:00:15:13	15
newark wifi	00:06:25:98:7A:0C	23

Location Sensing : Techniques

- **Fingerprinting**



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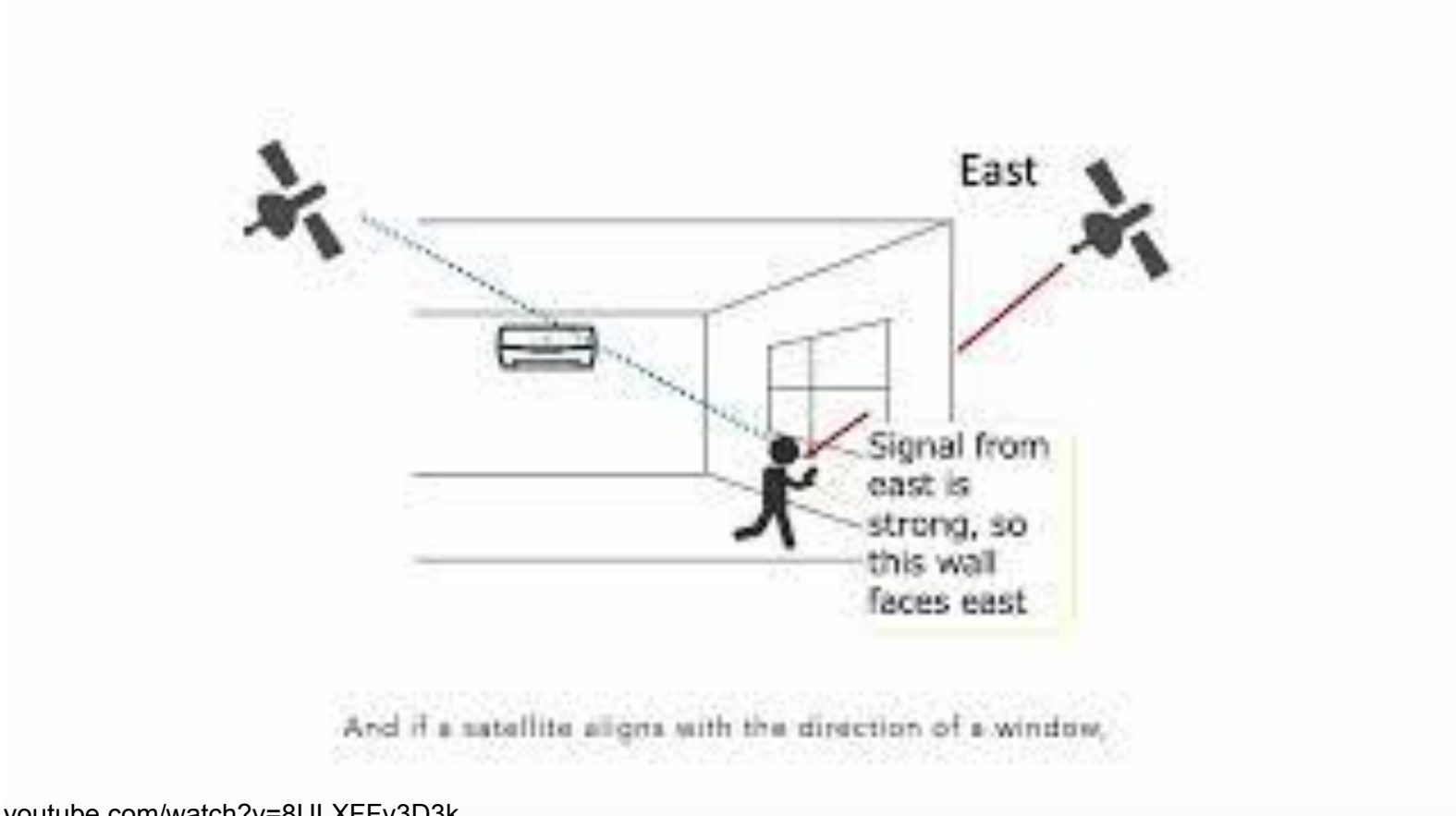
Location Sensing : Techniques

- **Dead Reckoning**
  - Dead reckoning is a location technique that computes the location of a device based on its previously known location, or fix, elapsed time, direction, and average speed of movement.
  - The assumption behind dead reckoning is that the direction and the average speed of movement since the last fix is either known or can be estimated.
  - Example of usage : when a car enters a tunnel and loses signals from GPS satellites.

Location Sensing : Techniques

- **Scene Analysis**
  - The scene analysis location sensing technique uses features of a scene observed from a particular vantage point to draw conclusions about the location of the observer or of objects in the scene.
  - Usually the observed scenes are simplified to obtain features that are easy to represent and compare.
  - In **static** scene analysis, observed features are looked up in a predefined dataset that maps them to object locations.
  - In contrast, **differential** scene analysis tracks the difference between successive scenes to estimate location. Differences in the scenes will correspond to movements of the observer and if features in the scenes are known to be at specific positions, the observer can compute its own position relative to them.

Location Sensing : Revisiting the Applications



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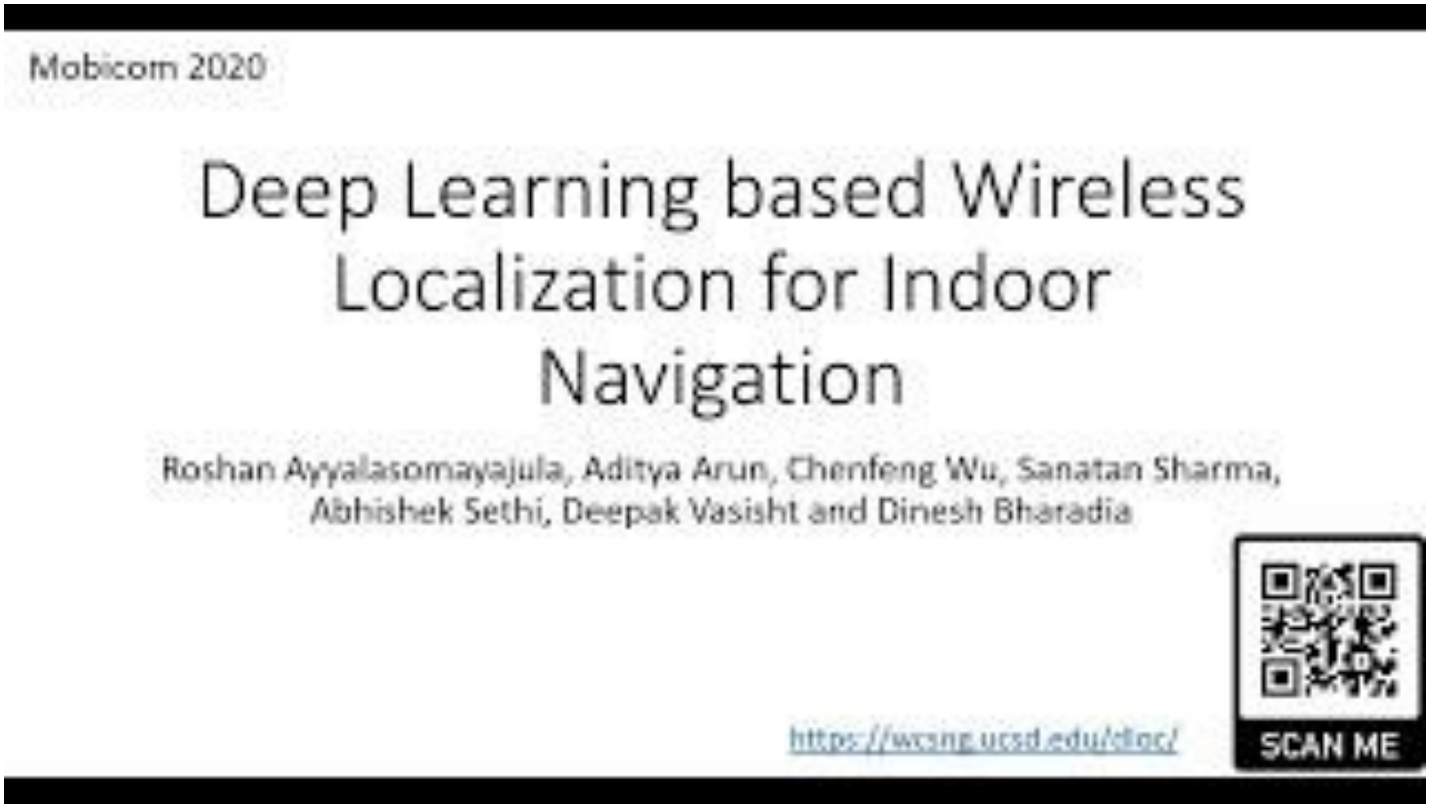
Location Sensing : Revisiting the Applications



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