Week 6: Location tracking and use

Constandache, Bao, Azizyan, and Choudhury. Did You See Bob?: Human Localization using Mobile Phones

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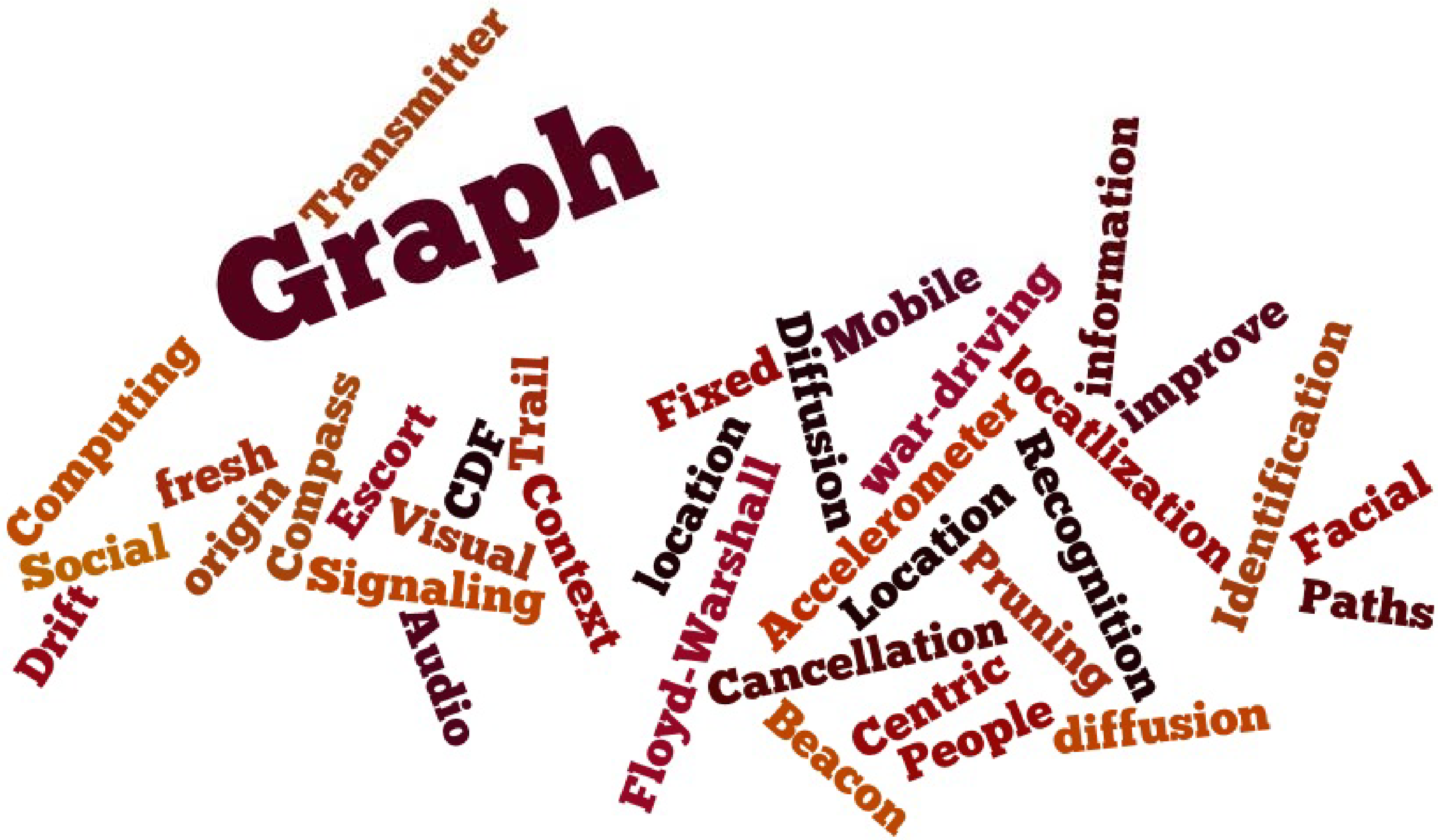
Collaborative Computing

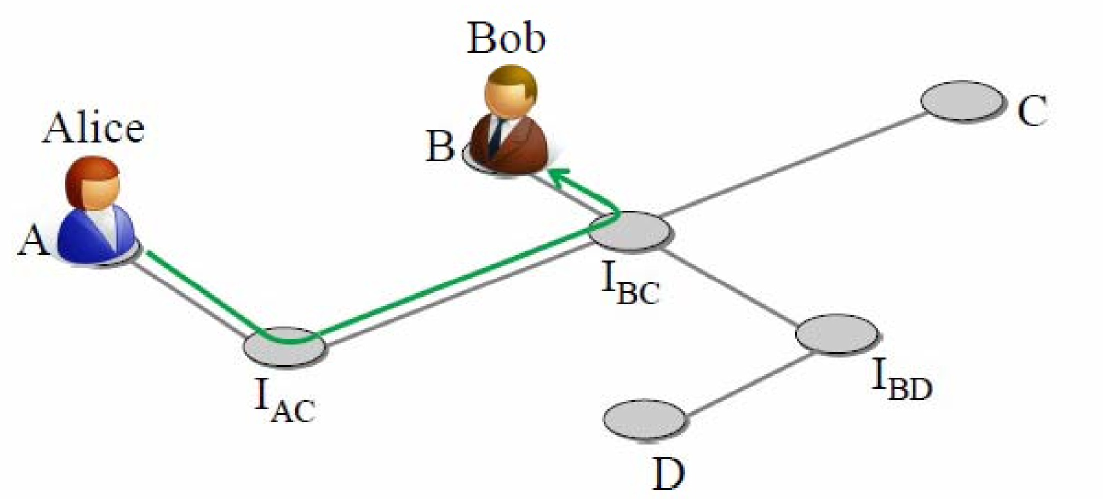


People Centric Mobile Computing "Needs Improvement"

- **GPS is accurate but drains batteries**
- **Expense of infrastructure and war-driving requirements**

“Expand the Notion of Localization to the Social Context”

- Have a 3rd person know the location of Bob
- Develop an electronic system that can localize and route a person A to a specified person B.



Capture Users “movement traces”

Challenges

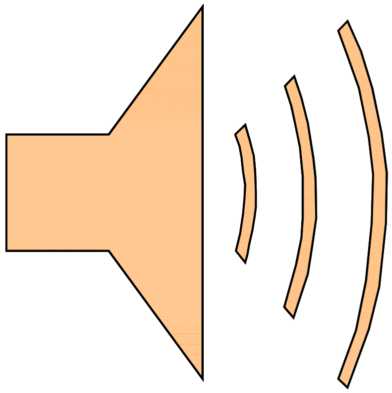
- Accelerometers and Compass in phones are noisy creating drift
- No global reference frames, no auto-correct
- Non-trivial to correct entire trail

Capture Users “movement traces”

Solutions

- Fixed Beacon Transmitter
- Location Diffusion
- Drift Cancellation

Simple to Install Stand-Alone System



- The beacon is placed in an arbitrary position likely to encounter foot traffic.
- Encounter detection is achieved by audio
- Encounters between other users and the beacon trigger corrections

System Overview : User Carried Mobile Phones

- Human walking patterns generate identifiable accelerometer signatures that can be multiplied by user step size to obtain approximate displacement
- Compass readings off the direction of movement
- Trail reported to server
- Due to sensor noise, trails drift
- Encounters with beacon and encounters with users correct positions and trails by reporting intersections to server
- Global view translates to Graph of trails
- Pruning Heuristics applied to simplify Graph.
  - For example, if you can walk one direction you can walk back that same direction.

Walking Patterns

Accelerometer

- Identify the walking pattern
- Displacement calculated by multiplying step size as a function of users weight and height
- Step accuracy 96% accurate on average

Compass Subtleties

Compass

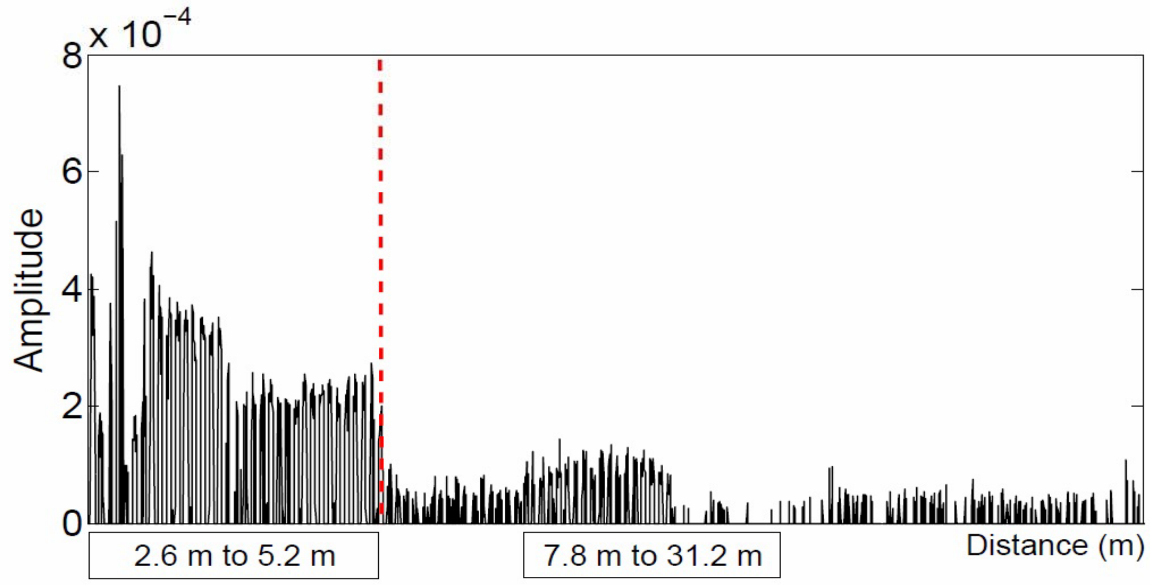
- Stabilize on a biased value
- After each turn a new bias is imposed
- Identified two states, walking in a continuous direction and turning.

Best efforts: actual locations to positional data, way off target

Encounter Detection

Audio decay

- **Tone amplitude used as primary (close enough to be there) calculation**



‘Diffusion’ Correction

Beacon considers itself origin of the virtual reference frame. Encounter with Beacon repositions at origin(0,0)

Escort users repositioned when encountering other users. System defers to most recently position users location (diffused)

‘Drift Cancellation’ Correction

- **Encounters provide opportunity to correct users entire trail history.**

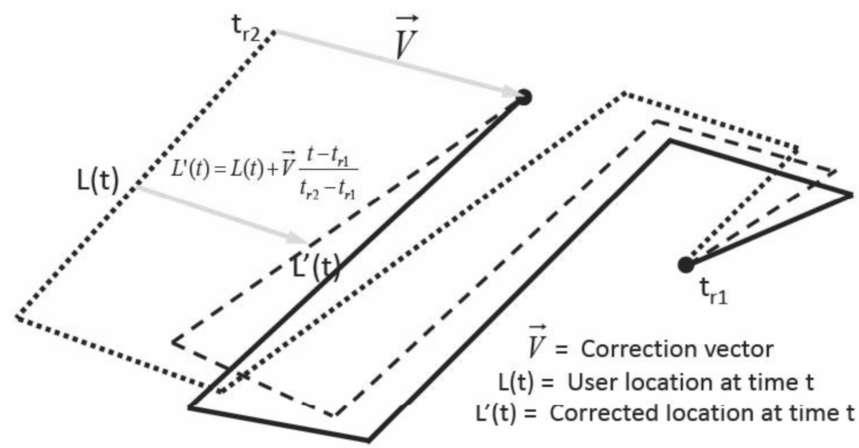
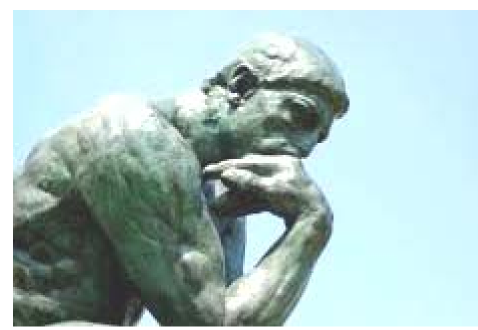


Figure 8: Drift Cancellation: the solid line is the actual user path, the dotted line represents the user computed trail, and the dashed line denotes the user trail corrected via Drift Cancellation.



Computing Routing Directions

Computes current position together with spatial intersections of the users' trails to build a trail graph.

- Spatial meaning that the users may have crossed each others path at different points in time

Other users building trail graphs

- **Creates noise – pruning heuristics: selects the closest intersection for both users other intersections are eliminated**
- **Joined Paths maintained**

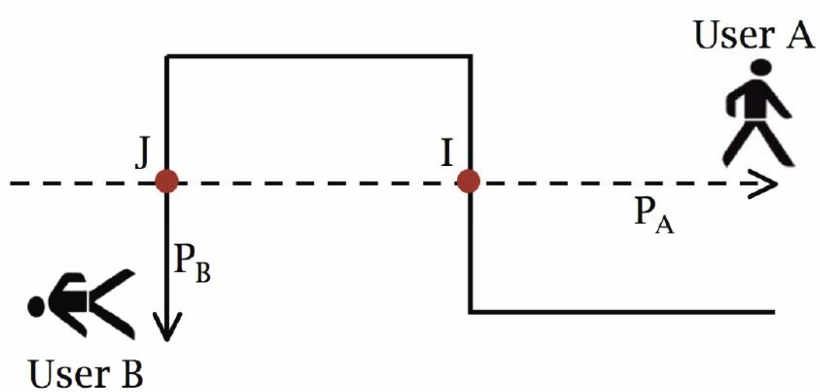


Figure 10: Spatial intersections between users.

Visual Identification

Users may not know each other.

Use phone to scan group and find Bob using features, such as clothing color, pre-configured when engaging system.

Phone may take picture of owner.

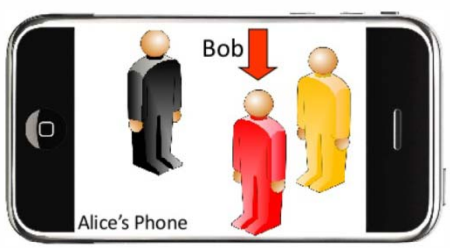


Figure 11: Camera-based user identification.

Methodology

Ran experiments in areas containing markers of known positions

- Parking Lot
- Indoor Building

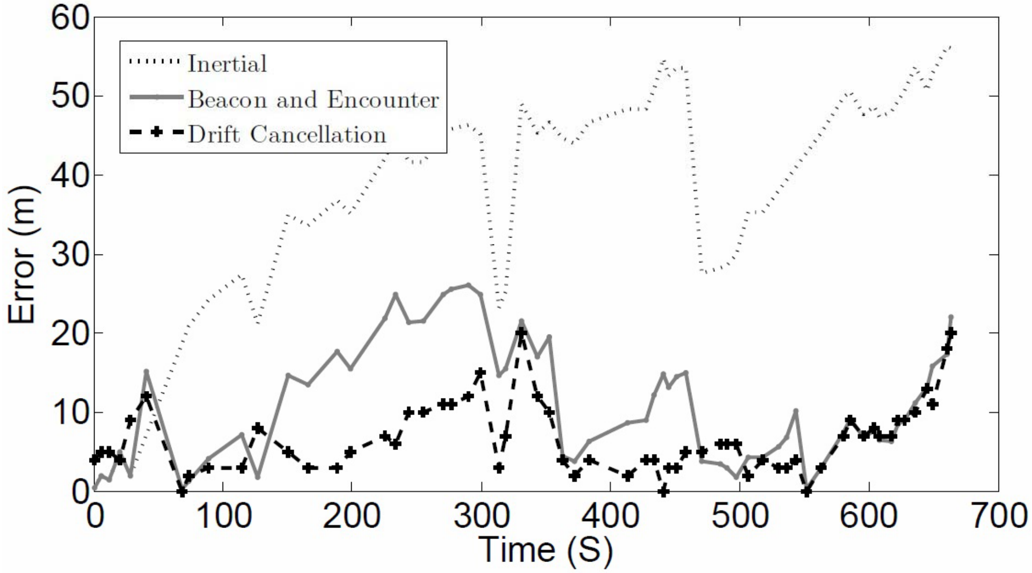
Two Stages. Two Metrics

- Collection
  - Shadowed Users with Clipboards
  - Instantaneous error as the difference between the actual positions recorded by the system and the known GPS positions
- Routing
  - Measured the difference in distance between the user and the final destination

Results

Two Metrics

- **Variation of Instantaneous Location Error**
- **The error in distance from where they should be and where they are.**



Indicates p. lot **ILE** evolves over time by three schemas.

Less pronounced in build. (confinement of rooms for users)

Limitations and Future Work

Not energy Efficient

- Consumes lots of battery power, many options for corrections

Routing through physical objects

- Humans can make educated decisions based on environment

Long Routing paths

- Even if A is close to B but goes around Cape Horn, could develop best path algo

Route instructions low location accuracy

- The further and longer they get away from encounter event. System could time them out.

Phone Placement

- Phone orientation may change the phones idea of where it is pointing. Better inference is already being investigated by other researchers

Behavior under heavy user load

- Claim will actually get better with more users

Conclusions

- Identifies the problem of social localization
- Location of user not necessary when a someone can follow the graph and get close enough
- Demonstrated the feasibility of this system

Questions