Outline

• Positioning Technology
• GPS and others
• Location Specifiers
• Privacy Issues
Universal Location

• On earth, we need three pieces of information:
  • latitude, longitude, & altitude
  • there are other possibilities
• Global Positioning Systems can give us that information
• Can then use mapping to do something useful with that information
Global Positioning Systems

• 1978 US Department of Defense begins project

• 1984 Crash of Korean Flight due to poor navigational equipment ==> gps for civilian use

• 1985 Complete system fully operational

• 24 satellites (11,000 mile orbit) & $12 billion

• 2000, selective availability turned off

• 3 to 15 meter accuracy for everyone
How it works

• Receiver measures travel time of random code sent from satellite (about 0.1 sec)
  • compute distance, call it X
• Receiver’s position can be anywhere on a sphere of radius X with satellite at center
• Given four satellite readings, can figure out position in 3 dimensions
• Let’s look at some government slides
  • mms.nps.gov/gis/gps/How_GPS_Works.ppt
GPS

• Python interface to a bluetooth gps

• Connect to the GPS normally:
  • from socket import *
  • sock = socket(AF_BT, SOCK_STREAM)

• Read input from ‘$’ up to a ‘\r’ character using the sock.recv(1) command (reading one byte at a time).
• `buf = sock.recv(1)`

• `while buf != '$': buf = sock.recv(1)`

• `while buf[-1] != '': buf += sock.recv(1)`

• `if buf[0:6] == "$GPGGA":`

  • `(GPGGA, utcTime, lat, ns, lon, ew, postfix, sats, hdop, alt, altunits, sep, sepunits, age, sid) = buf.split("\",")`

• `latitude = float(lat)`

• `longitude = float(lon)`
Image removed due to copyright restrictions.
Please see:
http://home.pacific.net.au/~gnb/gps/mnea.html
Image removed due to copyright restrictions.
Please see:

http://home.pacific.net.au/~gnb/gps/mnea.html
GSM Cellular location

• GSM mobile telephone network: cells
  • towers fixed, signal available indoors
  • unaffected by “urban canyon effect”
• CellID: detect base transceiver stations (BTS)
  • phone is registered with a BTS
  • usually, but not always, the closest one
GSM Cellular Location

• Cell size depends on terrain & number of users

• Error: about 500 m (urban) to 15km (rural)

• Base stations have 3 antennas, 120 degree sectors
Enhanced Method

• E-OTD: Enhanced observed time difference
• Time from base station to phone
• Time from base station to fixed location
• Ratio gives better estimation of position
• Also use triangulation (from several bases)
• Both yield order of magnitude improvement
• and lots of research for even better results
What good is GPS?

• It is universal
• But is it what we want?
• Human-centric versions of location:
  • name of place
  • map of place
Other Data Formats

• Geographic Information System (GIS)
  • developed set of XML descriptions
  • static (river): Geo Markup Language
  • dynamic (cars, events): Point-of-interest
• NVML: Navigation mark-up language
• SKiCAL: iCalendar VEVENT used to describe event information
• event meta-info: location
Spatial Databases

• Set of functions to
  • quickly search, query, analyze spatial info
  • how objects spatially relate to each other
• many geometry types and typical queries
People don’t speak GPS

- Different people have different views of the world.
Places -- big and small

- People refer to location as places
  - countries, cities, towns, streets, buildings
  - rooms, spaces within buildings
  - relation to other places,
    - e.g. across from Starbucks
- GPS is too precise and may require accurate map or building plan
  - Jim might be at 42.3325N, -71.11861E but is he in the shower at the moment?
Location Tracking: Good, Bad, or Ugly?

• Not too many people seem to be concerned about location-based services tracking them.

• “You have no privacy, get over it”

•-- Scott McNealy, CEO Sun
Can we study this?

• Before investing heavily in location-based services, we should find out if people will use them.
• The evidence is still mixed
<table>
<thead>
<tr>
<th>Service</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service A: Ringing profiles</td>
<td>The mobile phone 'knows' when the user is in a meeting or in class</td>
</tr>
<tr>
<td>in private settings</td>
<td></td>
</tr>
<tr>
<td>Service B: Ringing profiles</td>
<td>The mobile phone 'knows' when the user enters a movie theater or a restaurant</td>
</tr>
<tr>
<td>in public settings</td>
<td></td>
</tr>
<tr>
<td>Service C: Lunch service</td>
<td>A suggestion for lunch is pushed by the retailer to the mobile phone when the</td>
</tr>
<tr>
<td></td>
<td>user is around a restaurant or fast food place</td>
</tr>
<tr>
<td>Service D: Localization of</td>
<td>The mobile phone can locate predefined friends and alert the user when they</td>
</tr>
<tr>
<td>predefined friends</td>
<td>are within a certain distance</td>
</tr>
</tbody>
</table>

Location-Based Services.
<table>
<thead>
<tr>
<th>Service</th>
<th>Rated usefulness</th>
<th>Rated Intrusiveness</th>
<th>Average# of daily use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service A: Private ringing profiles</td>
<td>3.75</td>
<td>2.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Service B: Public ringing profiles</td>
<td>2.6</td>
<td>2.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Service C: Lunch service</td>
<td>2.2</td>
<td>3.7</td>
<td>0.3</td>
</tr>
<tr>
<td>Service D: Localization of predefined friends</td>
<td>3.75</td>
<td>3.25</td>
<td>1.3</td>
</tr>
</tbody>
</table>

1 = not useful at all, 5 = very useful
1 = not intrusive, 5 = very intrusive

**AVERAGE RATING OF THE SERVICES**

Figure by MIT OCW.
<table>
<thead>
<tr>
<th>Services</th>
<th>Personalization</th>
<th>Passive Context-Awareness</th>
<th>Active Context-Awareness</th>
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<tr>
<td>A: Private ringing profiles</td>
<td>Different ringing profiles that are set manually</td>
<td>The phone prompts the user to adjust the profile when sensing it is in a meeting or class</td>
<td>The phone automatically changes profile when sensing the user is at a meeting or class</td>
</tr>
<tr>
<td>B: Public ringing profiles</td>
<td>Different ringing profiles that are set manually</td>
<td>The phone prompts the user to adjust the profile when sensing it is in a movie theater or at a restaurant</td>
<td>The phone automatically changes profile when sensing the user is at a movie theater or at a restaurant</td>
</tr>
<tr>
<td>C: Lunch service</td>
<td>Manual search for appropriate lunch place</td>
<td>Single alert around noon for lunch place according to user's preferences</td>
<td>Alerts the user when passing by a lunch place or relevance and suggests places at noon.</td>
</tr>
<tr>
<td>D: Class slides</td>
<td>Manual search to see if class slides are available online</td>
<td>If signed up, the phone alerts user of available slides for class</td>
<td>Automatic alert every time the teacher updates class slide website</td>
</tr>
<tr>
<td>E: Location tracking</td>
<td>Manual location tracking of predefined friends</td>
<td>Locations tracking of friends and setting to alert when they are within a certain range</td>
<td>Location detection of friends that alerts when they are within 300 feet of user</td>
</tr>
<tr>
<td>F: Activity tracking</td>
<td>Display of potential call-receiver's social situation (e.g. meeting, home, out)</td>
<td>In a new context, the phone prompts the user to display the user's situation to possible callers</td>
<td>Automatic switch to display of social situation when entering a new context</td>
</tr>
</tbody>
</table>

The three levels of services presented to participants.
Does Age Matter?

- Not much in this sample of 23 participants.
- Surprising result

<table>
<thead>
<tr>
<th>N = 23</th>
<th>Personalization</th>
<th>Passive Context-Awareness</th>
<th>Active Context-Awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>8</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Average Age</td>
<td>23.7</td>
<td>22.9</td>
<td>25</td>
</tr>
<tr>
<td>Average Mobile Phone Ownership</td>
<td>2.2 Years</td>
<td>2.6 Years</td>
<td>2.7 Years</td>
</tr>
<tr>
<td>Average User Level (a scale from 1-6)</td>
<td>3.1</td>
<td>3.8</td>
<td>3.4</td>
</tr>
</tbody>
</table>

General participant demographics.

Figure by MIT OCW.
Their Conclusions