Cognitive Geolocation

Learning Location by Listening to the Radio

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Overview

- Geolocation
- Cognitive Radios
- Cognitive Geolocation
- Methods
- Emulab
- Measurements and Database
- Analysis
- Results
- Conclusion
Geolocation

- What is Geolocation
- Disadvantages of GPS
  - Does not work well in urban areas
  - Disruption of signals by building walls
- Find an alternative for urban areas
- The electromagnetic spectrum
Cognitive Radios

- What is a cognitive radio
  - Smart radio
  - Makes use of unoccupied bands
- Need knowledge of band occupation
- Band occupation varies with position
- Need knowledge of position for allocation
- Cognitive Geolocation
  - Uses spectral activity to its advantage
Cognitive Geolocation

- Examines the spectrum
  - Signals differ from one position to another
  - Compare the measured spectrum to a database
- Uniqueness of the spectrum enables one to determine position
Methods

- Use a radio to scan the spectrum
- Typical spectrum analyzers are very expensive
- Use USRP (Universal Software Radio Peripheral) Devices, which are much cheaper
- Require GNU radio software
- Advantage of GNU radio
  - Software based
  - Programmable
  - Flexible

[1]
Methods Continued

- Need to build a database
- Need measurements from various locations
- Need many samples for a database
- Need simultaneous measurements
Emulab

- Research lab provided by the CS department
- Has a network of USRP nodes
  - Can be controlled remotely
  - Can be programmed to take simultaneous measurements
Measurements and Database

- Taken using usrp_spectrum_sense.py
- Measurements are of the spectrum power
  - Complex value (real, imaginary)
  - 824-960MHz
- Organized for easy access
  - Date --> time --> location --> 10 measurements
- Database
  - Average of 530 measurements
  - 18th-20th of November of 2007 during morning and afternoon hours
  - Created for 9 locations

\[ power = \sqrt{r^2 + i^2} \]
Analysis

- Additional measurements were taken
  - 9:30-11:15pm December 4, 2007
  - 10:00am-12:30pm December 5, 2007
- Matlab programs developed
  - Take the average of multiple measurements
- Difference between this average and the 9 database files is taken

\[ d(x, y) = \sum_{i} 10 \cdot |\log_{10} x(i) - \log_{10} y(i)| \]

- Smallest difference is the match
Results

- Correct location determined
  - 91% of the time for day samples
  - 80% of the time for night samples
- Example: MEB 3118 vs. Database

<table>
<thead>
<tr>
<th>Room</th>
<th>MEB 3118</th>
<th>3137</th>
<th>3145</th>
<th>3146</th>
<th>3240</th>
<th>3355</th>
<th>3436</th>
<th>3520G</th>
<th>4160</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diff in dB</td>
<td>118</td>
<td>281</td>
<td>153</td>
<td>193</td>
<td>205</td>
<td>197</td>
<td>215</td>
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Results

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Results

Mismatching location

Matching location
Conclusion

- Relatively constant spectrum over time
- Changing spectrum with location
- Customized database yields better results
- Cognitive Geolocation can be used to determine location
References
