Positioning with coverage area estimates generated from location fingerprinting

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http://math.tut.fi/posgroup/
Outline

- Coverage area estimation
- Positioning with coverage area estimates
- Example
Coverage area estimation

Measurement model:

\[ Y = 1_n \mu^T + \epsilon, \text{ where } \epsilon_{(i)} | \mu, \Sigma \sim N_p(0_p, \Sigma) \]
Coverage area estimation, Bayesian prior $p(\mu, \Sigma)$
Coverage area estimation, Likelihood $p(Y|\mu, \Sigma)$
Coverage area estimation, Posterior $p(\mu, \Sigma | Y)$

Probability that location $p$ is in the coverage area of CN $c$ follows normal distribution

$$p|c \sim N_p(\mu, \Sigma)$$
List \( \mathbf{c} = (c_1, c_2, \ldots, c_n) \) of CNs heard at position \( \mathbf{x} \), \( c_i = (\mu_i, \Sigma_i) \)
Positioning

- List $\mathbf{c} = (c_1, c_2, \ldots, c_n)$ of CNs heard at position $\mathbf{x}$, $c_i = (\mu_i, \Sigma_i)$

- $\mathbf{x} \sim N_p(\hat{\mathbf{x}}, \mathbf{C})$, where
  \[ \hat{\mathbf{x}} = (\sum_{i=1}^n \Sigma_i^{-1})^{-1}(\sum_{i=1}^n \Sigma_i^{-1} \mu_i) \]

  and
  \[ \mathbf{C} = (\sum_{i=1}^n \Sigma_i^{-1})^{-1} \]
$R = \bigcup_{p=0}^{3}\{R^p_i| i \in ID\}$, where $R^p_i = (\mu^p_i, \Sigma^p_i)$ is formed using location reports, where transmission power $t \leq p$
### Example

<table>
<thead>
<tr>
<th>Errors:</th>
<th>mean [m]</th>
<th>68 % [m]</th>
<th>95% [m]</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test points, $R$</td>
<td>8.1</td>
<td>9.1</td>
<td>21.9</td>
<td>9.8</td>
</tr>
<tr>
<td>Test points, $R_i^3$</td>
<td>8.7</td>
<td>10.3</td>
<td>22.1</td>
<td>10.7</td>
</tr>
<tr>
<td>Headnode mean</td>
<td>11.8</td>
<td>15.3</td>
<td>30.4</td>
<td>14.0</td>
</tr>
</tbody>
</table>

- **True position**
- **Coverage area**
- **Position estimate**
- **Headnodes**
- **Mean**
Conclusion

- Bayesian prior improves the coverage area estimate
- Algorithms allows a closed form solution
- Uses only IDs of CNs as measurements, signal strength is not needed to improve results
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Thank You!
Questions?