Step 7) Motion model (OPTIONAL FOR BAYES)

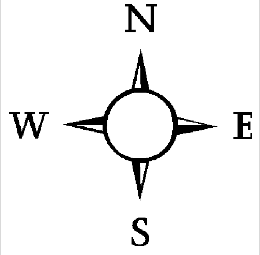
- Differentiate between idle and walking (we won't run :)
- Count number of steps *s*. Two options:
  - Preferred: TYPE_STEP_COUNTER (API 19 and higher)
  - Autocorrelation/Fourier transform (will be taught in class)
- For stride/time length assume
  - stride length (s) = height x 0.4 + noise
- Hence given location x, the new location distribution at each step is:

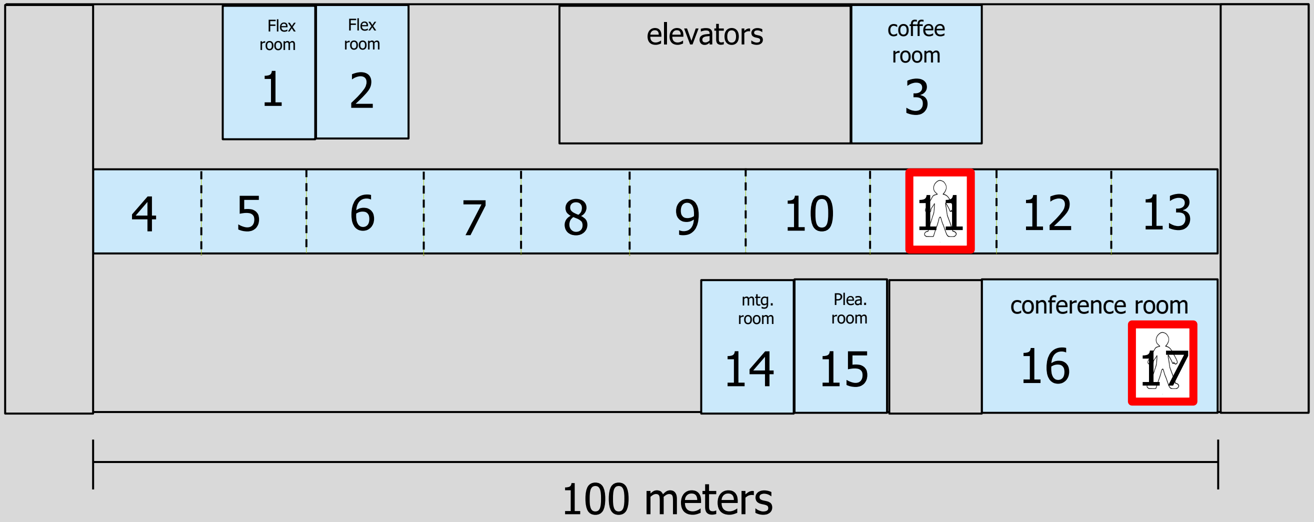
$$[(x-s)+noise,\ (x-s)-noise]\ \cup\ [(x+s)-noise,\ (x+s)+noise]$$

- Use compass to identify exact direction. Two options
  - Preferred: TYPE_ROTATION_VECTOR
  - Sensor fusion (will be taught in class)

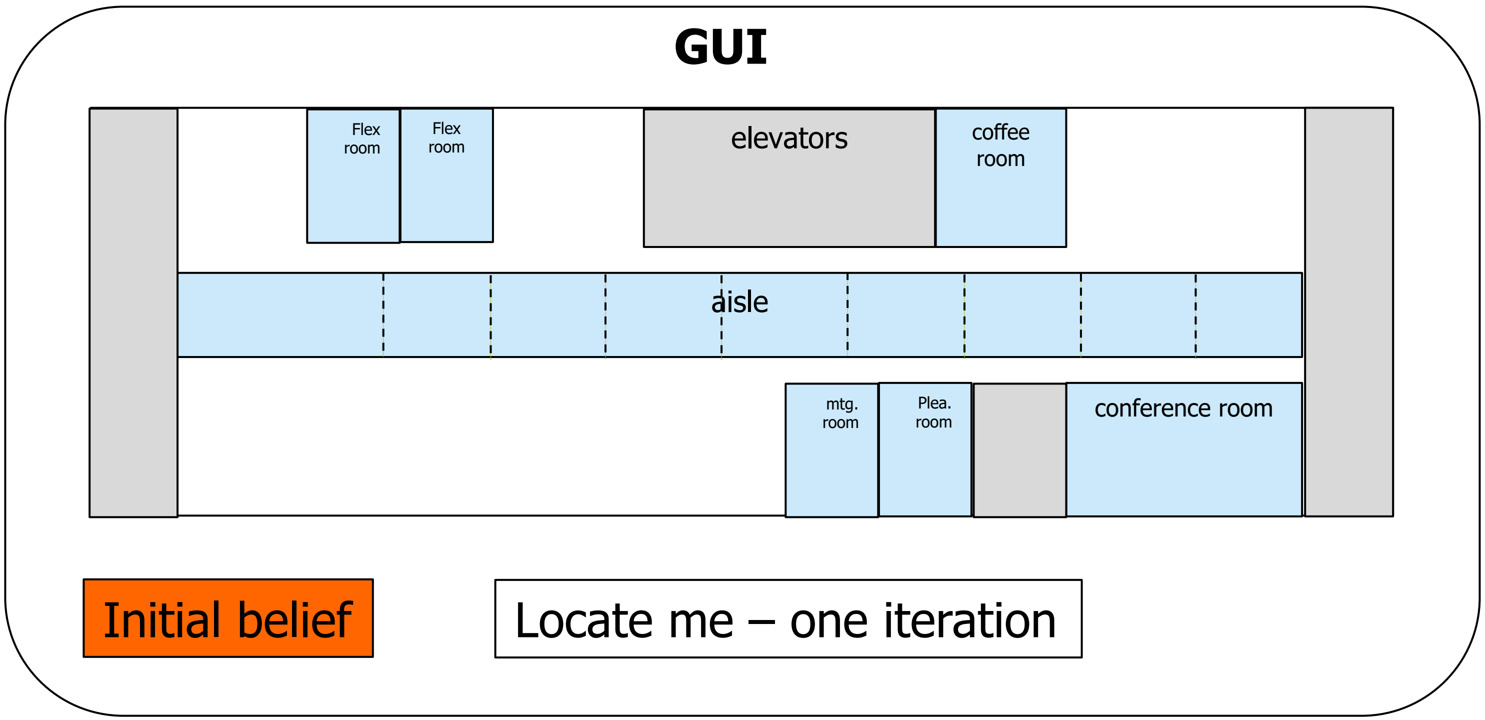
Advantages of motion model

A user has equal probability of being in cells 11 and 17 (p=0.5 each). The user walks 40 meters West, which cell or cells have the highest probability of being the correct location of the user after the 40 meter walk? Why?

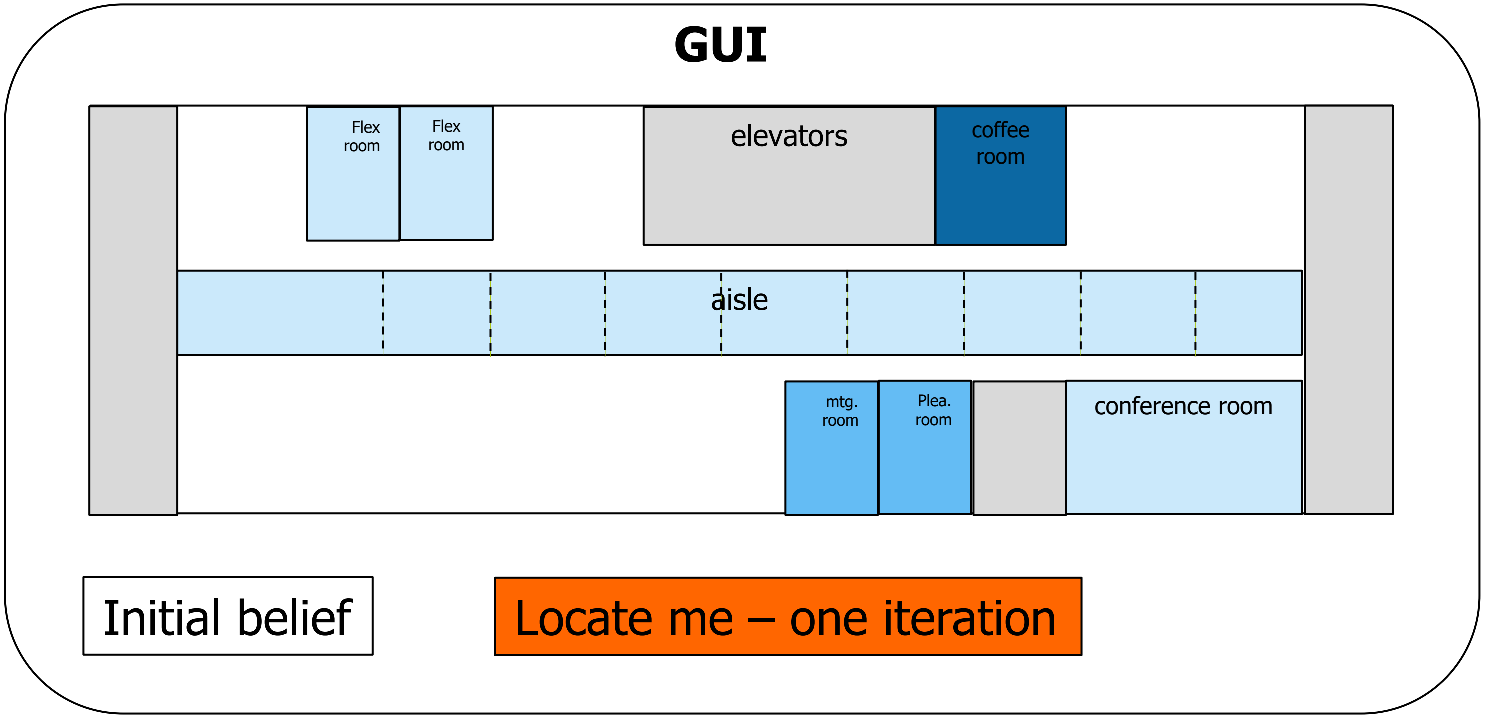




App: remember no training on the spot

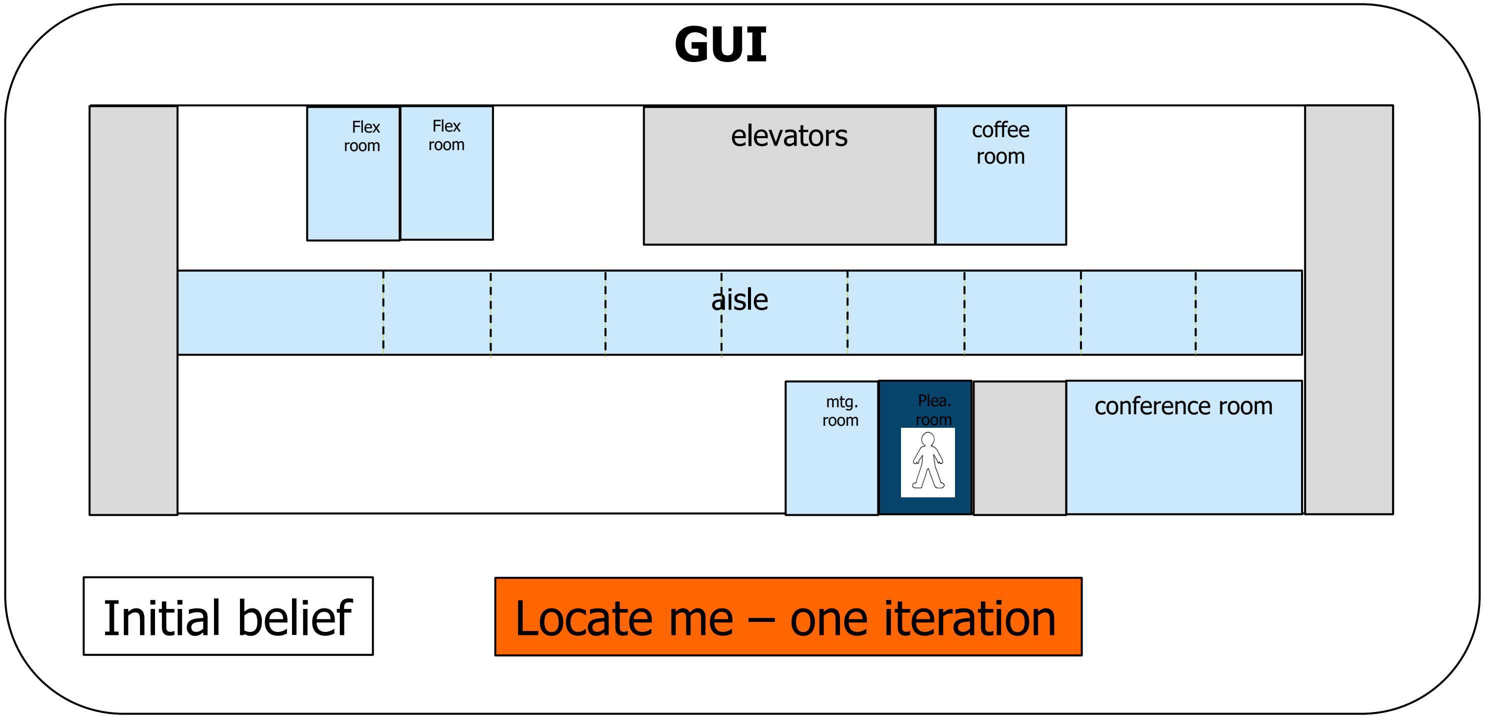


App: update belief



we will push "Locate me" until the app converges

App: update belief



Minimum requirements for your location (Report 2)

- Total area: 70 square meters.
- Eight ***contiguous*** cells
- The cells can be inside and outside your apartment.
- Each cell should have a maximum of 9 square meters (any shape).
- At least four cells should NOT have walls in between them.

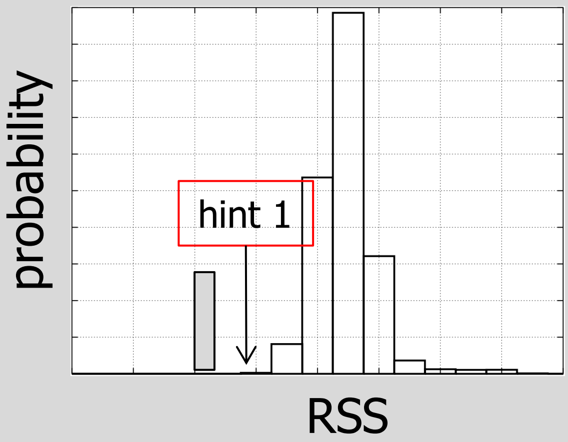
Off line processing

- Off line processing can be very useful to have a good understanding of a method.

- Gather data for each cell, say 5 minutes per cell.
- Divide samples at random in a training and testing sets.
- Build Bayesian filter in Java/Python/Matlab with training set and check accuracy with testing set.
- Gather data at different days (multipath fading)

NEAT TRICKS FROM PRIOR WORK

Modeling radio maps



RSS values for AP j

pmf of cells

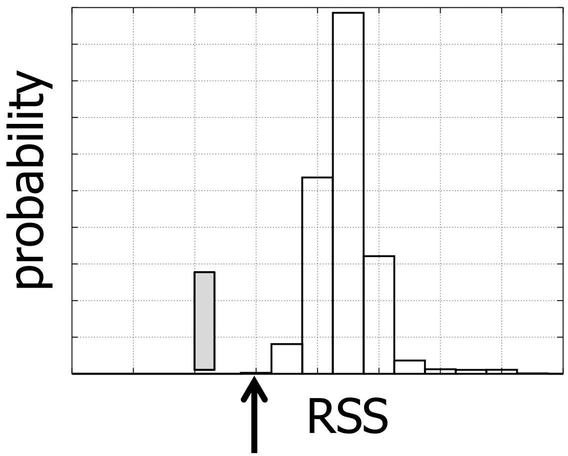
	0	…			r		…	255
C1								
Ci			0.1	0.2	0.5	0.2		
C17								

We suggested to use tables to store radio maps. But tables have limitations. Which ones?

hint 1: empty space cause by gray bar in pmf

hint 2: you may detect hundreds of Access Points at each scan.

Modeling radio maps



RSS values for AP j

pmf of cells

	0	...			r		...	255
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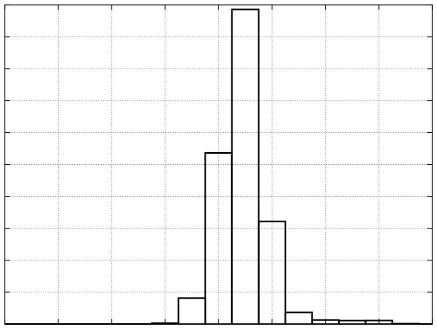
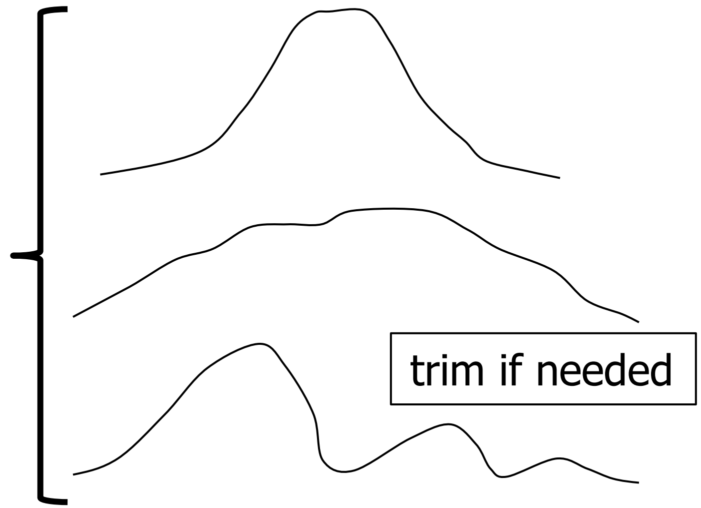
- We suggested to use tables to store radio map
- But tables have limitations
  - Sampling granularity
    - What if you get an RSS value that is not present?
  - Memory space
    - If you have N access points, you need 255xCxN elements

Modeling radio maps with Gaussians



This looks like a
Normal/Gaussian distribution

use Gaussians
for all cases

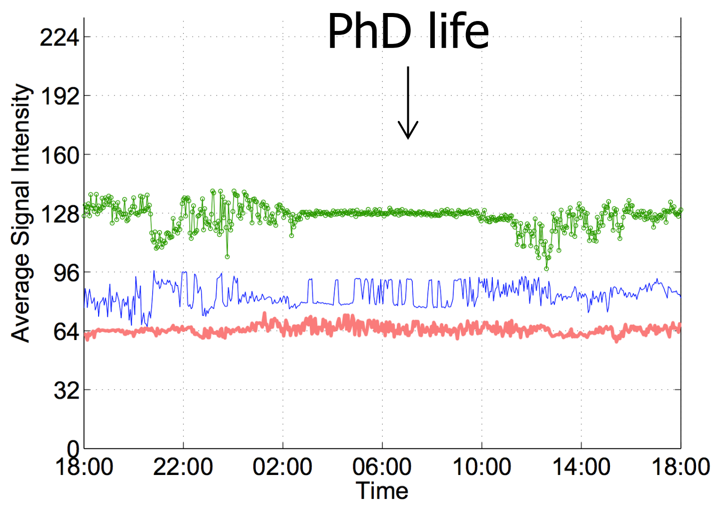


- Less memory space: 2xCxN (2 from 255)
- More granularity: $f(x,\mu,\sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$

Other students have used Gaussian Kernels and interpolation

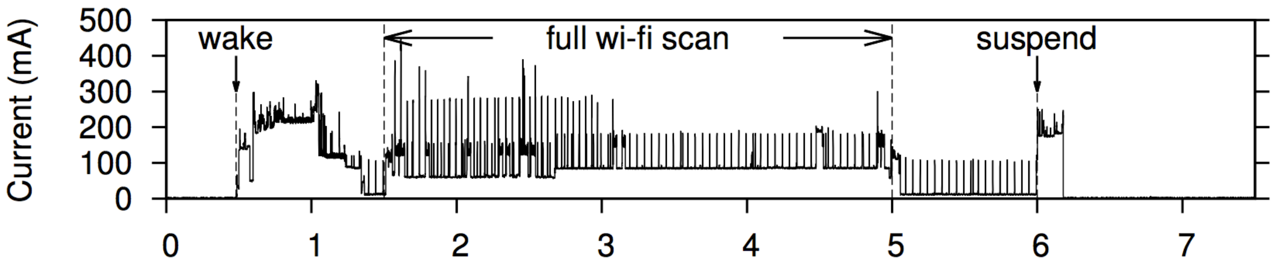
Modeling variance

- Check your testing phase at different days!
  - 2.4 GH-> 12.5 cm.
  - Multipath fading occur due to small changes
  - People moving, opening closing doors



Concrete sampling guidelines

- Horus (Bayesian grid)
  - 100 samples per cell spaced 300 ms, cell size:1.5m or 2.0 m
  - Error 2 meters
- Practical Robust Localization (Bayesian room)
  - 60 seconds sampling per office, cell size: 2.5 x 5.0 meters (500 offices)
  - 95% accuracy with 2 or 3 RSS measurements
- Both methods provide few meters error for 1-minute sampling per cell.
- WiFi scans take a few seconds. ***Make sure RSSI samples are different!***
  - Dual band phones may bring new results. Extra: compare 2.4 and 5 GHZ bands?



Diminishing returns

- Work hard but smart in your localization app.
- More training and testing data does not necessarily mean much better results, but it may mean more work, time and use of resources (memory, processor)

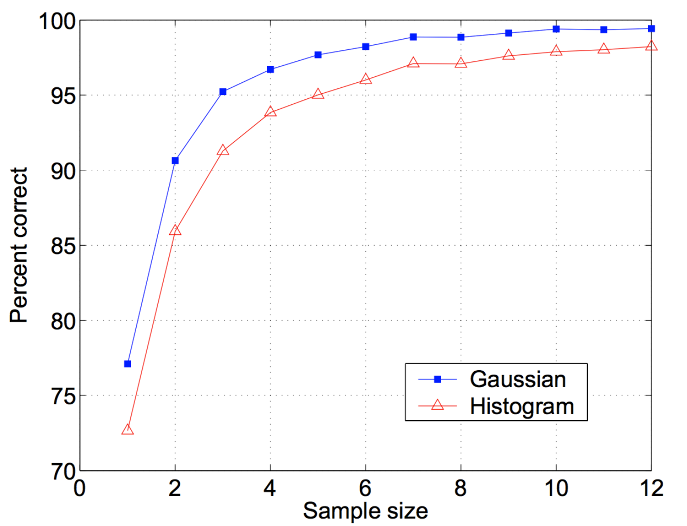


Figure 3: Bulk accuracy of localization methods after different numbers of observations.

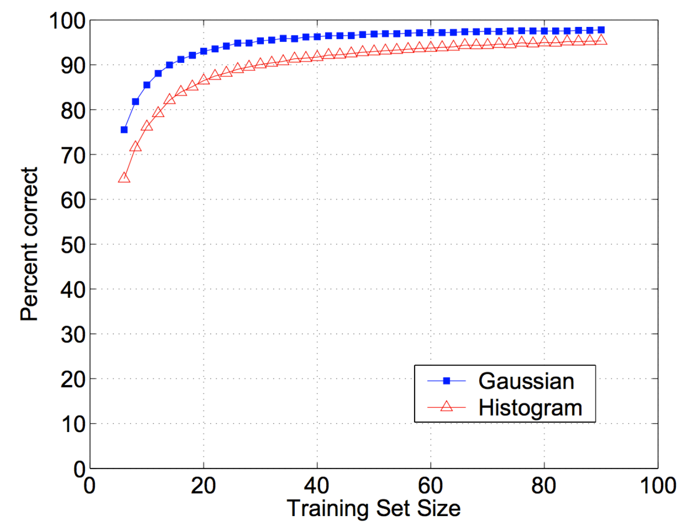


Figure 4: Training set size versus accuracy for the Gaussian and histogram methods.

Still major changes can happen on the day of evaluation affecting wireless channels. Do not despair! We will consider several attempts and external causes.

But if you have your app working ahead of time, make an appointment earlier to test it. It will help all of us.

Log normal shadowing model

TAMING RF SIGNALS

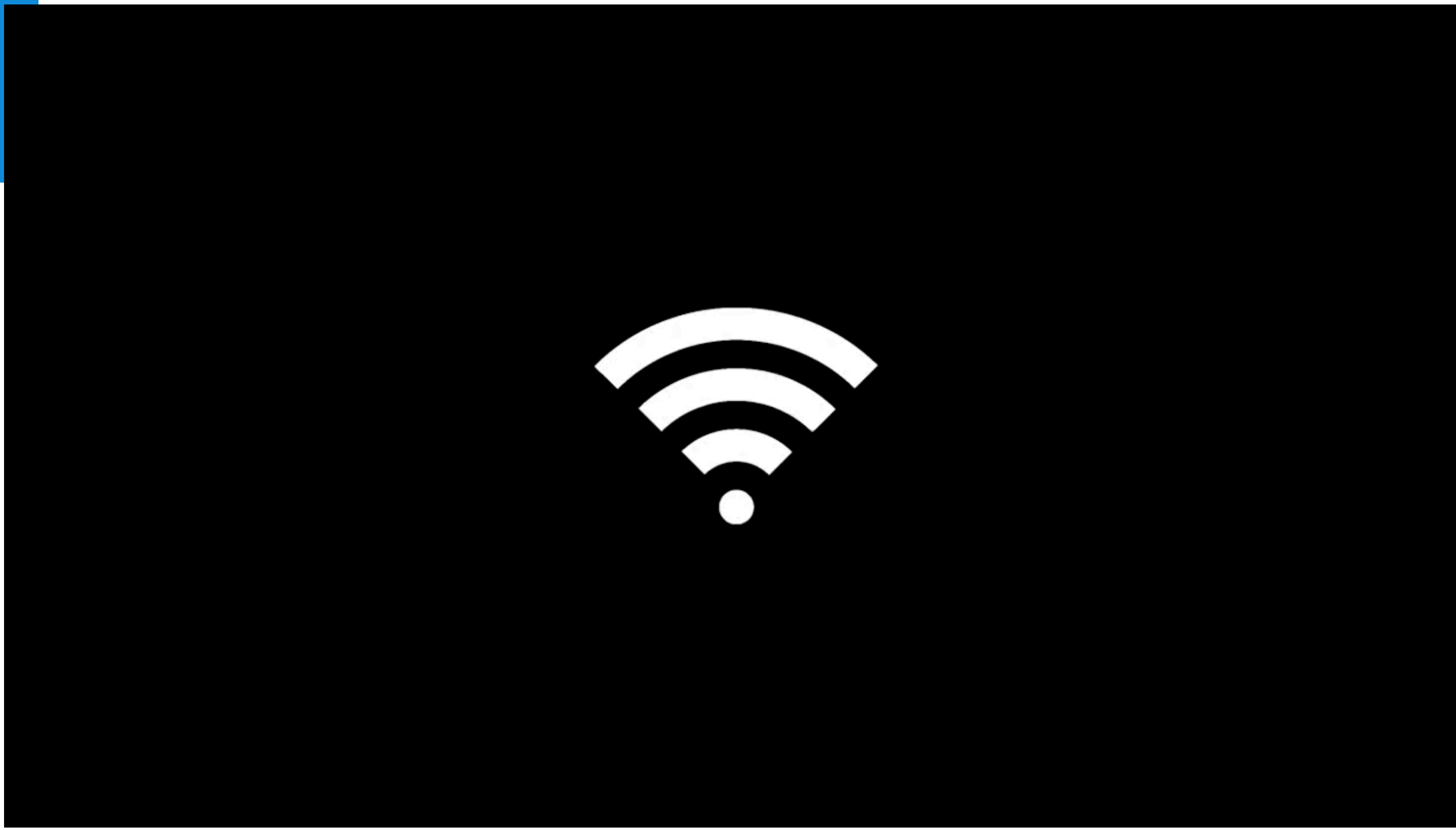
Log Normal Model

Understanding and taming radio signals

- Large-scale fading
- Small scale fading

Image taken from https://www.newscientist.com/blogs/nstv/2011/03/invisible-wi-fi-signals-caught-on-camera.html

Immaterial WiFi



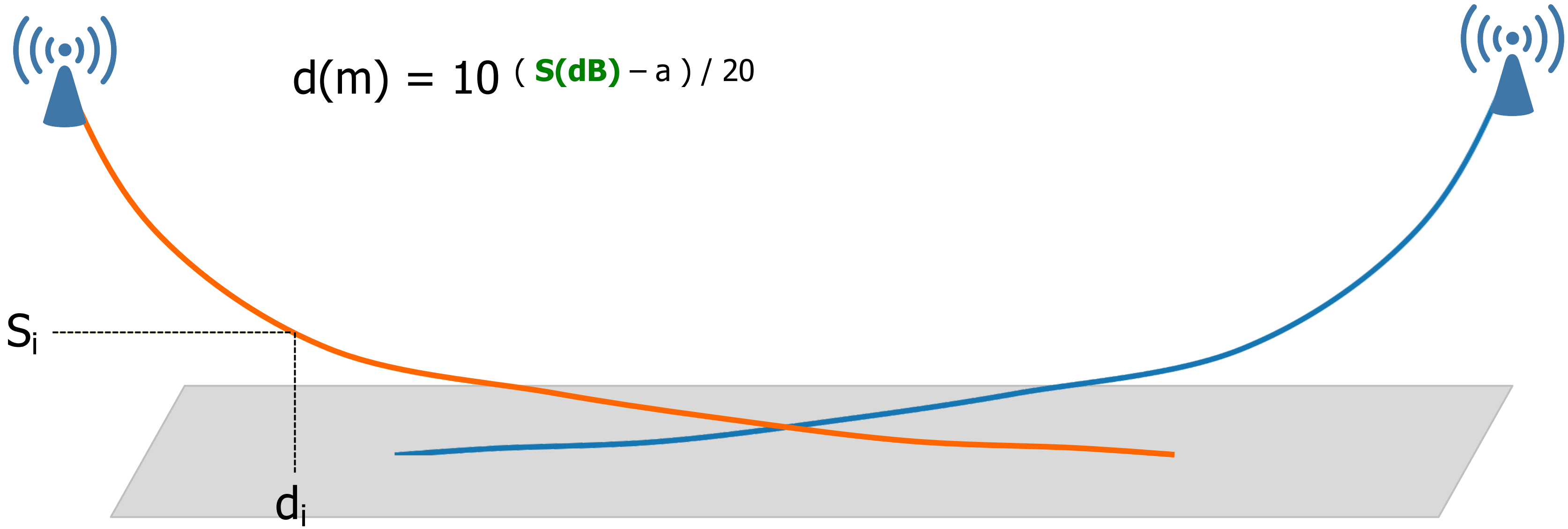
Problem definition: ideal RF localization

Path loss exponent

constant = a

$$S(dB) = 20\log_{10}(d) + \underbrace{20\log_{10}(f) + 20\log_{10}(4pi/c)}_{\text{constant} = a}$$

$$d(m) = 10^{(\,S(dB) - a\,)/20}$$



Localization with perfect RF signals is trivial, but there are no perfect signals in the wild.

Problem definition: ideal RF localization

Path loss exponent

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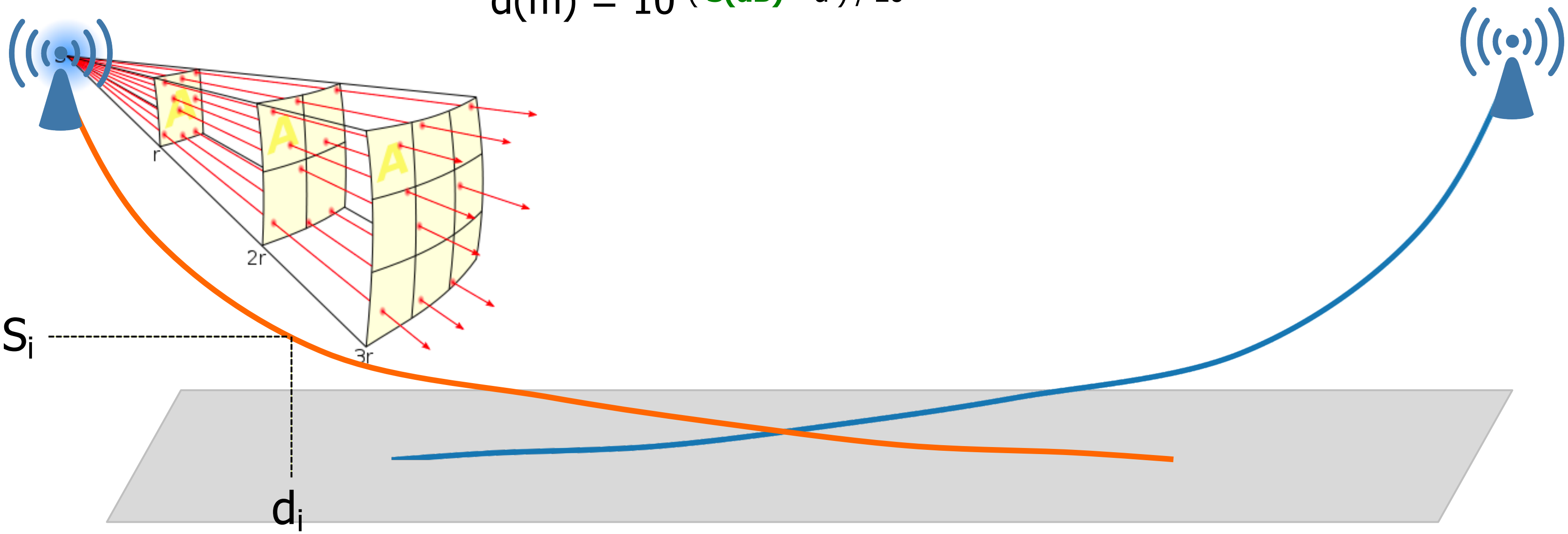
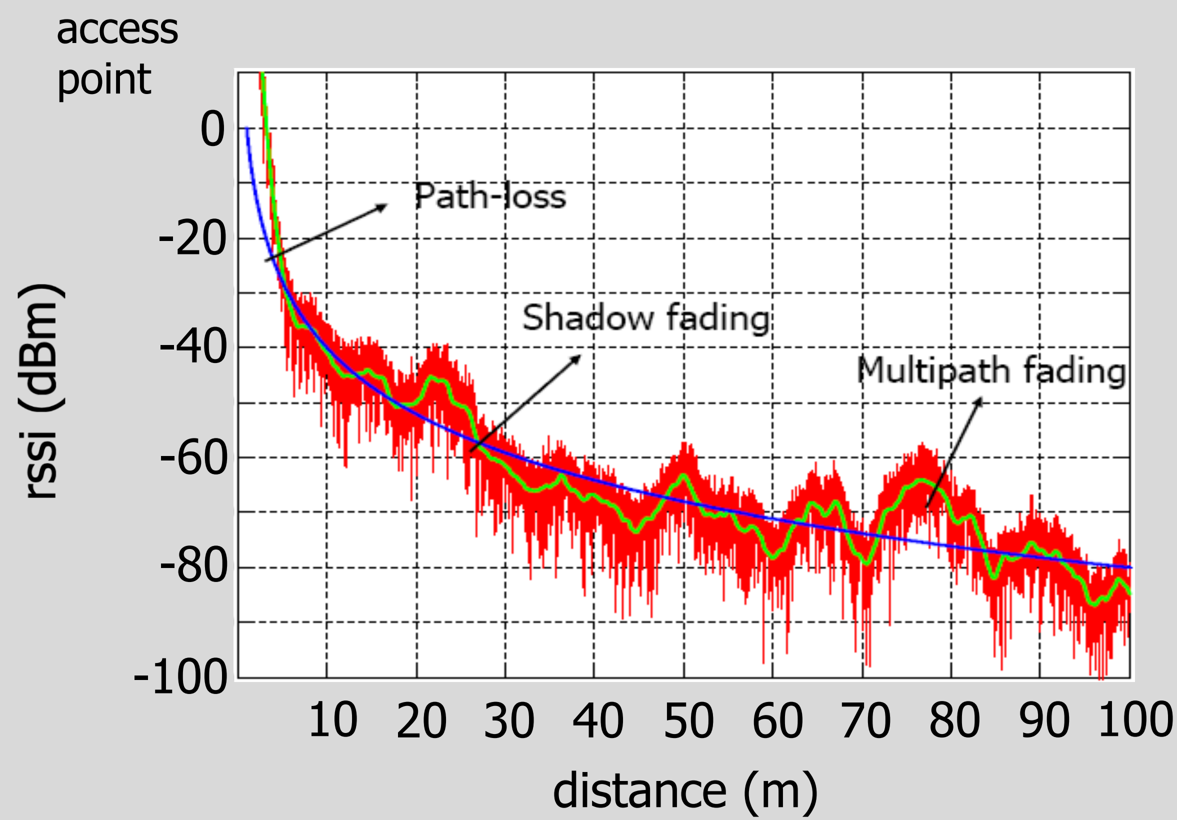
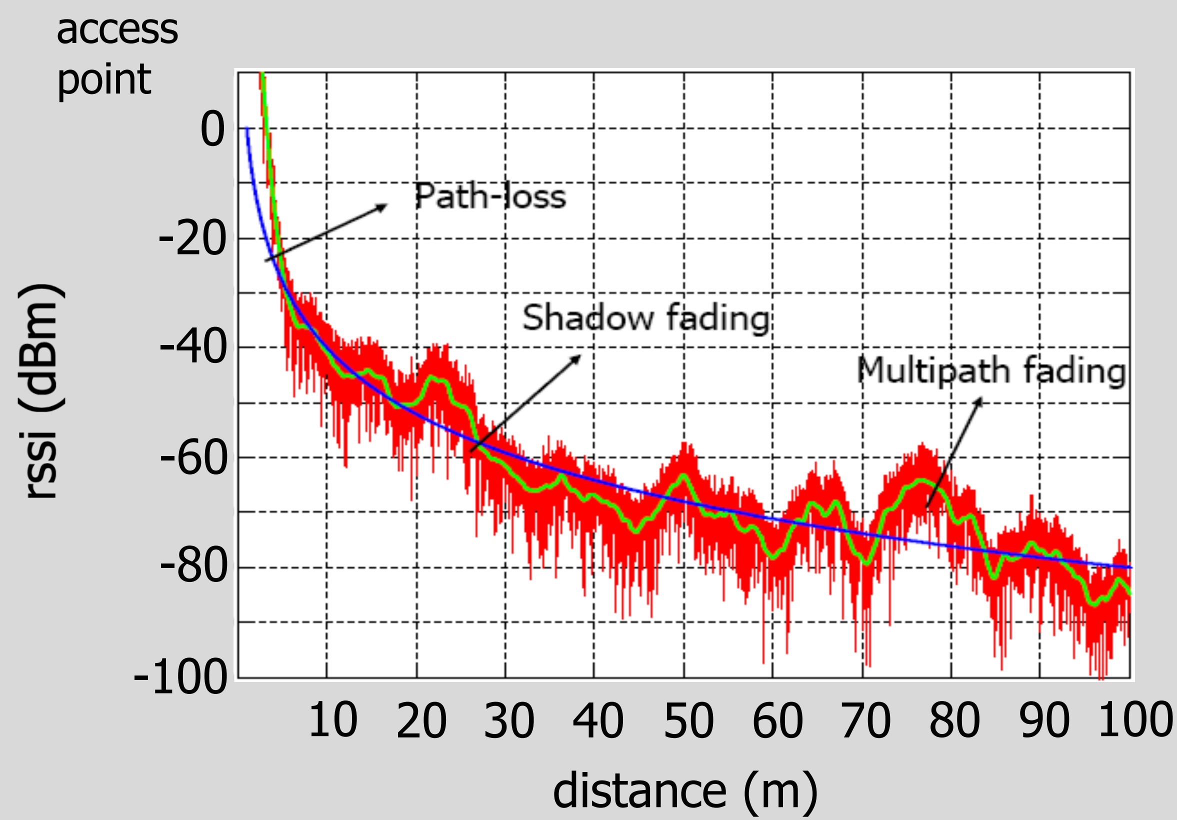


Localization with perfect RF signals is trivial, but there are no perfect signals in the wild.

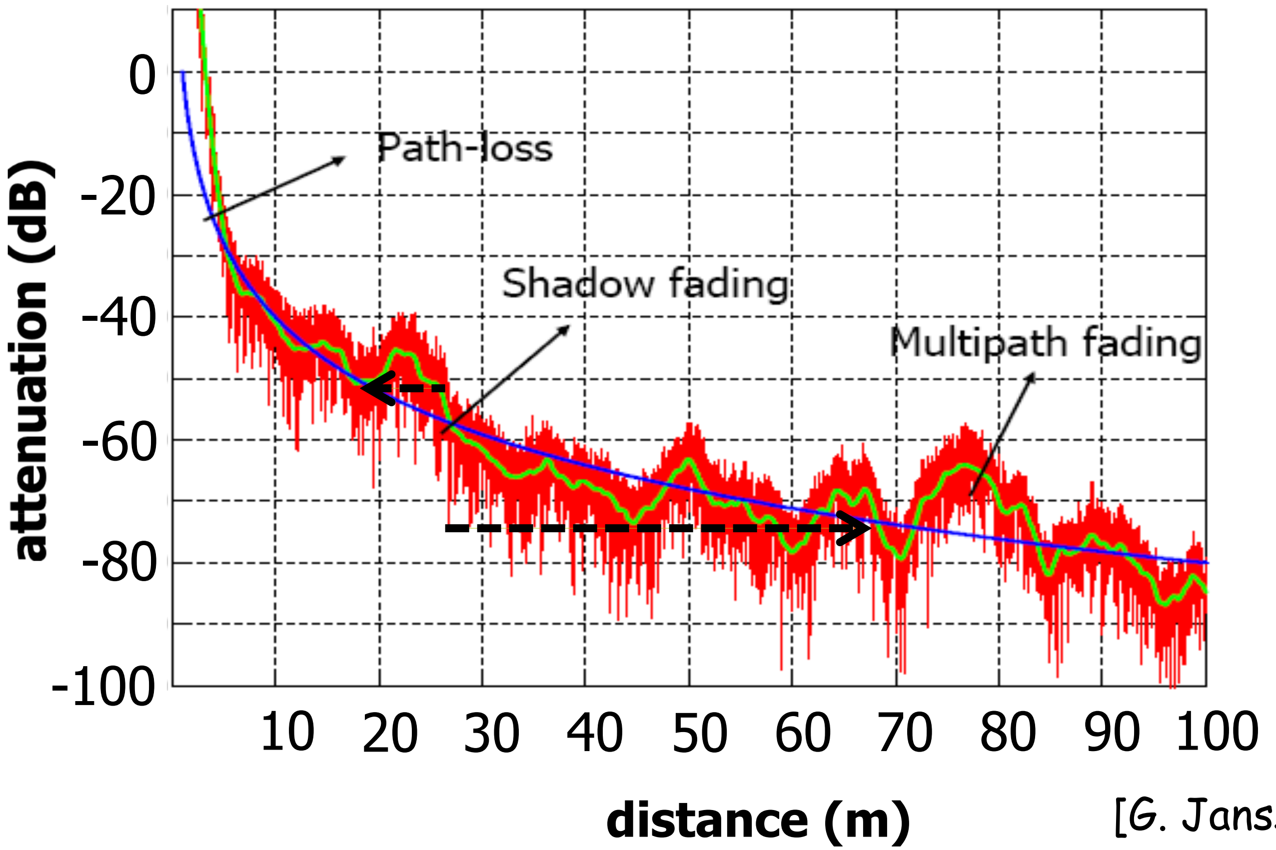
A user measures an rss value of -60 dBm, how far is the user from the access point? Use the blue curve as the training model.



A user measures an rss value of -60 dBm, how far is the user from the access point? Use the red curve as the training model.



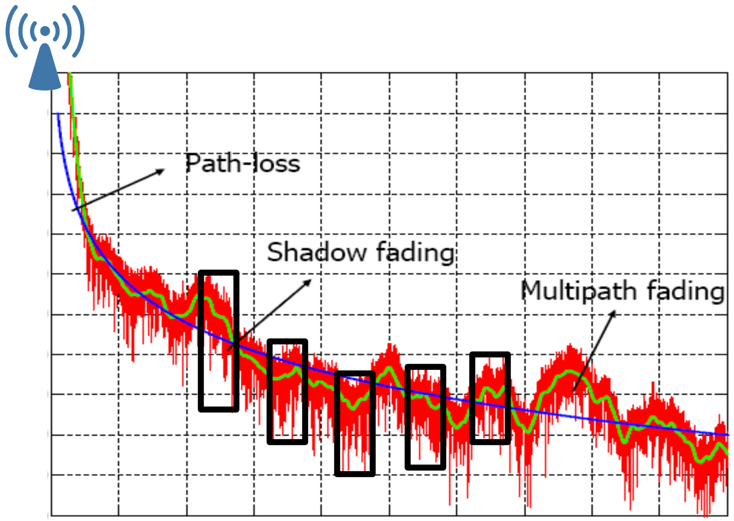
Problem definition: real RF localization



[G. Janssen, ET4358]

50m range!

RF fingerprinting



What problems do you think shadow and multipath fading will cause with KNN methods?

This is part of your first App