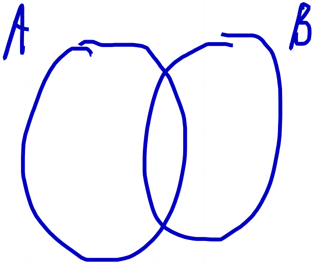
LOCALIZATION

BAYES THEOREM



$$\underbrace{P(A|B)}_{\text{prob. of event A given that event B has happened.}} = P(A\cap B)P(B)$$

prob. of event A given that event B has happened.

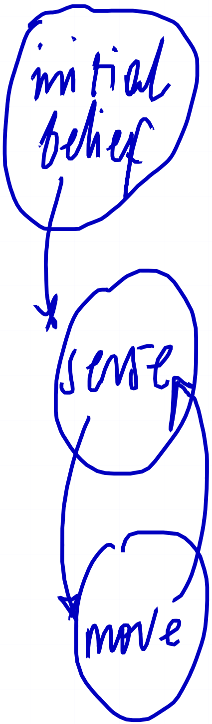
1. $P(A|B) = P(A\cap B)/P(B)$
2. $P(B|A) = P(A\cap B)/P(A)$

$$\boxed{P(A|B) = \frac{P(B|A)\,P(A)}{P(B)}}$$

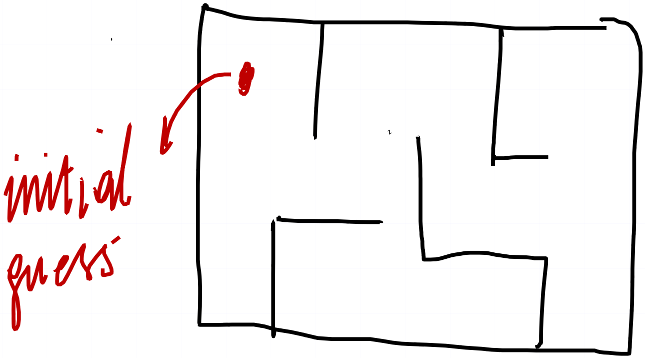
$$P(B) = \sum P(B|A)P(A)$$

normalization

BAYES FILTERS



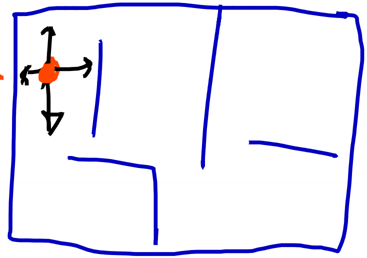
assume that we have a map



x → location

z → measurement

(1) sense: z_0
initial guess: x_0



(2) sense: z_1

$$\underbrace{P(x_1 | z_1)}_{\text{I sensed } z_1 \text{ and I am at } x_1} = \frac{P(z_1 | x_1) P(x_1 | z_0)}{\underbrace{P(z_1 | z_0)}_{\text{I sensed } z_1 \leftarrow z_0}}$$

I am at x_1 and I sensed z_0 and z_1

$$\overbrace{\underbrace{p(x_k \mid z_{1:k})}_{\text{Current Belief}}}^{\text{POSTERIOR}} = \frac{\overbrace{P(z_k \mid x_k)}^{\text{sense}} \; \overbrace{P(x_k \mid z_{1:k-1})}^{\substack{\text{PRIOR} \\ \text{from last step}}}}{\underbrace{P(z_k \mid \overline{z_{1:k-1}})}_{\text{normalization}}}$$

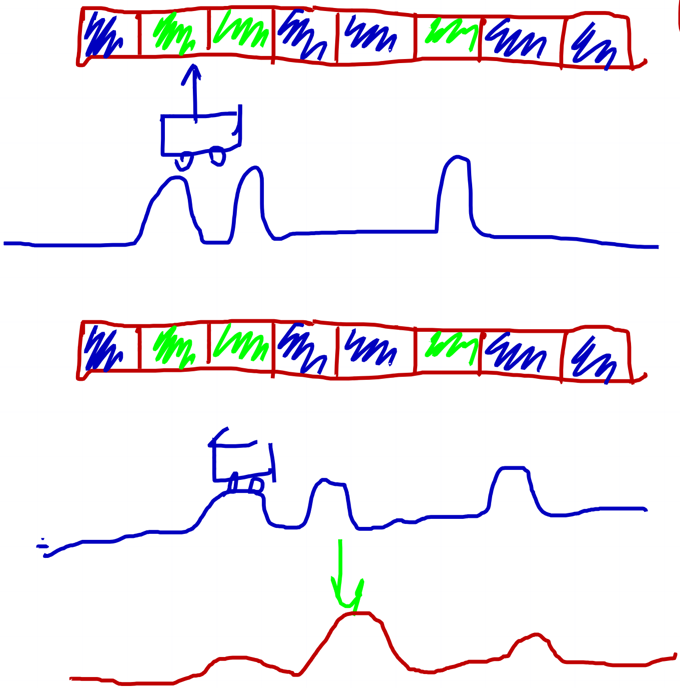
I measured $z_{1:k}$ and I am at location x_k

$z_k, z_{k-1}, \dots, z_1$

MOVEMENT

$$\underbrace{P(x_k \mid z_k)}_{\text{current}} = \int \overbrace{P(x_k \mid x_{k-1})}^{\text{motion model}} \underbrace{P(x_{k-1} \mid z_{1:k-1})}_{\text{from last step}} \, dx_{k-1}$$

EXAMPLE



(we have a map)

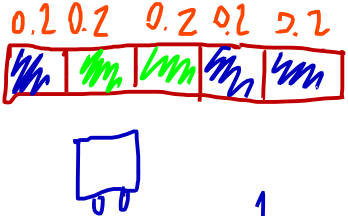
sense (green)

(move right)

(new prior)

sense (green)

posterior



initial belief

Assume that we sensed "green"

Our model:

$$P(z=g \mid x_i=g) = 0.6$$
$$P(z=b \mid x_i=g) = 0.4$$
$$P(z=b \mid x_i=b) = 0.8$$
$$P(z=r \mid x_i=b) = 0.2$$

we know these values from our previous measurements

PRIOR

0.2 0.2 0.2 0.2 0.2 $\quad P(x)$ } initial belief

0.2 0.6 0.6 0.2 0.2 $\quad P(z=g \mid x_i)$

0.04 0,12 0,12 0,04 0,04 $\rightarrow P(z=g \mid x)\, p(x)$

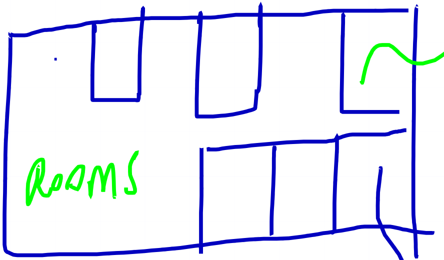
$$\Rightarrow P(x_k \mid z_{1:k}) = \frac{P(z_k \mid x_k)\, P(x_k \mid z_{1:k-1})}{P(z_k \mid z_{1:k-1})} \rightarrow P(z_k) = 0{,}36$$

NORMALIZE

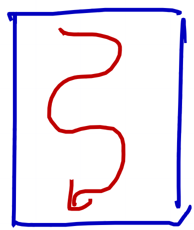
$\frac{0{,}04}{0{,}36} \quad \frac{0{,}12}{0{,}36} \quad \frac{0{,}12}{0{,}36} \quad \frac{0{,}04}{0{,}36} \quad \frac{0{,}04}{0{,}36}$

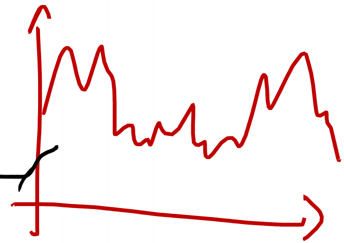
$1/9 \quad 1/3 \quad 1/3 \quad 1/9 \quad 1/9$ $\rightarrow$ POSTERIOR

A REALWORLD EXAMPLE



(1) For each room gather signal strength (WIFI signal)

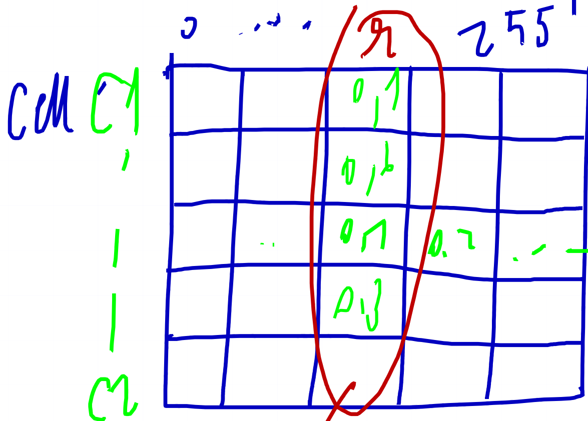




Filter and clean data

each room has a different RSSI histogram

We have a radio map for each cell.

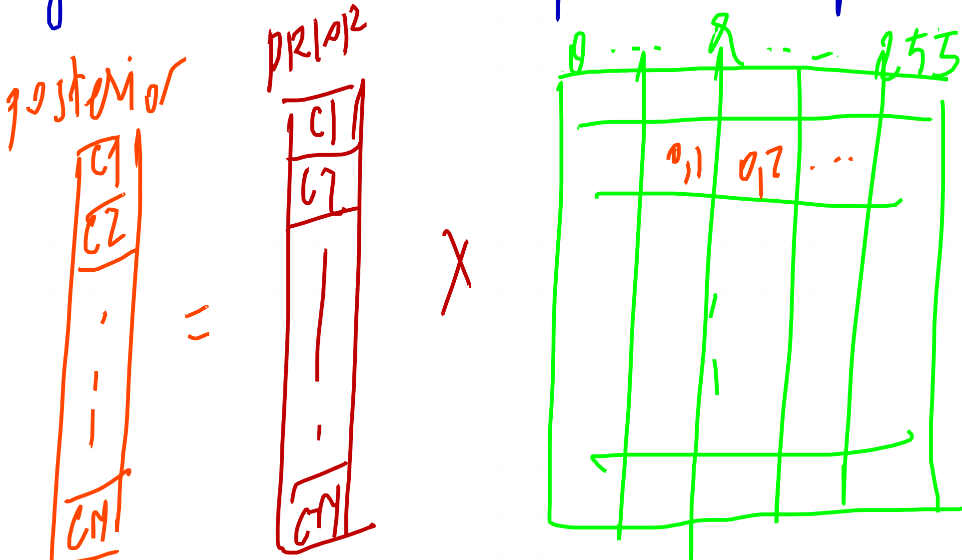


probability of each RSSI value

$$\sum p_i = 1$$

if we measure an RSSI value of r; we can reason about what's the location more likely.

Probability of I am in cell i given I got a measurement r from acces point j



j RSSI probability for each cell

(NORMALIZE!!!)

Summary

1. Get an RSSI map for each location
2. get an initial belief
3. sense the environment
4. update your belief using the sensed value and the map.

$$P(A|B) = P(A \cap B) / P(B)$$
$$P(B|A) = P(A \cap B) / P(A)$$
$$P(A|B) = \frac{P(B|A)\,P(A)}{P(B)}$$

denote $X \to$ location, $Z \to$ measurement

$$\boxed{P(x_i|Z) = \frac{P(Z|x_i)\,P(x_i)}{P(Z)}} \to \text{BAYES FILTER}$$