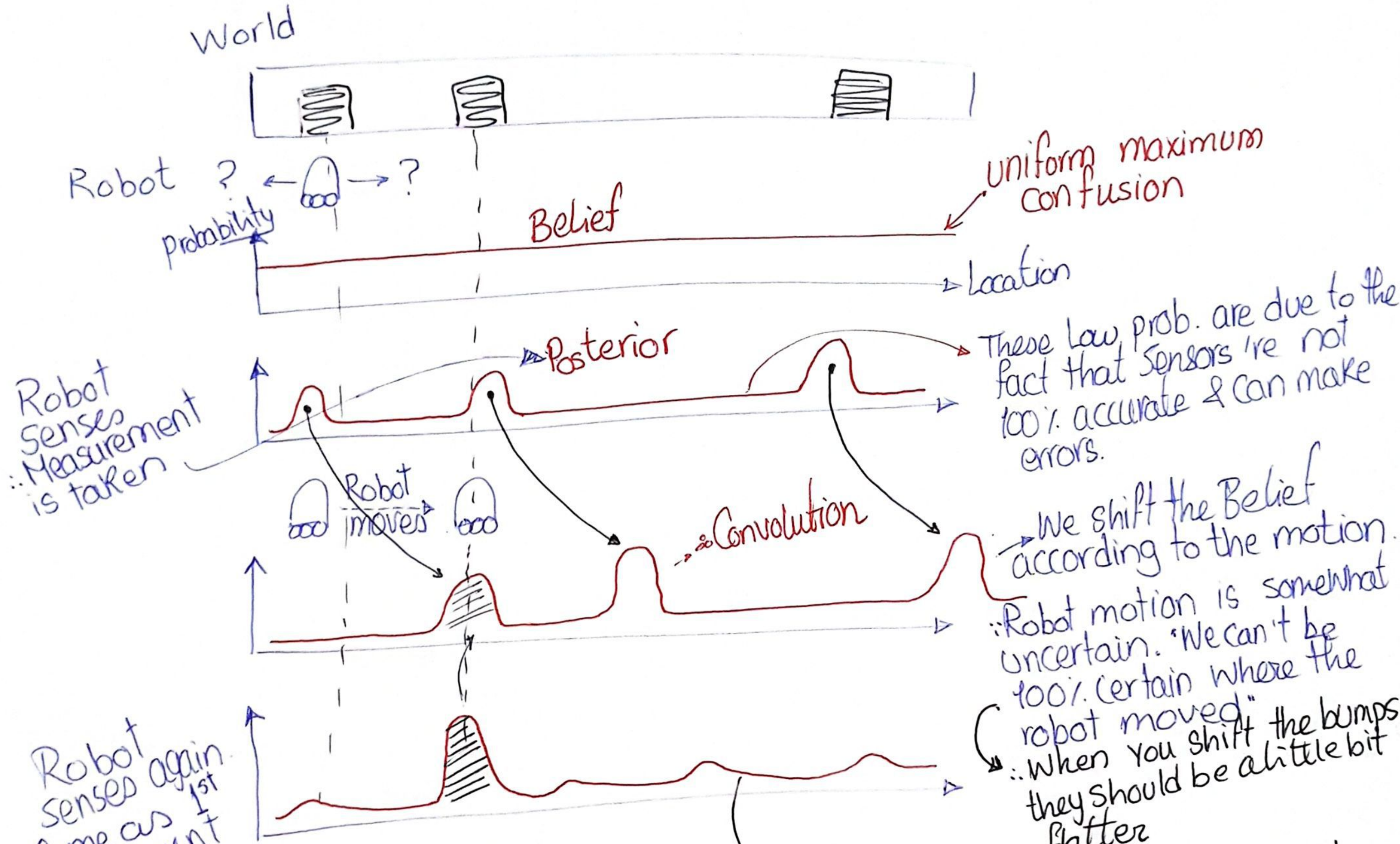
Localization

How Can We Know where we are with 10 cm Accuracy?



Multiply our belief, which is now prior to the 2nd measurement

→ We get a distribution which focuses most of its weight under the correct hypothesis.

- **Probability After Sense:**

0.2	0.2	0.2	0.2	0.2

×0.6
×0.2

0.04	0.12	0.12	0.04	0.04

$\therefore \Sigma \neq 1 = 0.36$

∴ Divide all by 0.36

↳ Normalization

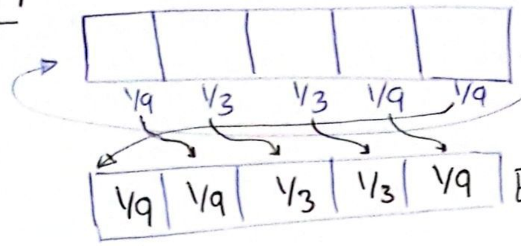
1/9	1/3	1/3	1/9	1/9

$\Sigma = 1$

$P(X_i \mid Z)$

"Posterior distrib. of x_i given measurement Z"

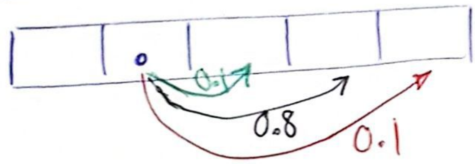
• Robot Motion



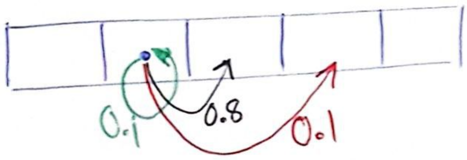
Exact Motion "Perfect Robot"

Inaccurate Robot Motion

This is the primary reason why localization is hard, bec. robots're not accurate.



$U = 2$



$U = 1$

ex.1

0	0.5	0	0.5	0

$U = 2$

0.4	0.05	0.05	0.4	0.05 0.05

$= 0.1$

$P(X_{i+2} | X_i) = 0.8$

$P(X_{i+1} | X_i) = 0.1$

$P(X_{i+3} | X_i) = 0.1$

∴ 2 possible ways to come here:
1. Over shooting @ 2nd cell
2. Under shooting @ 4th cell

ex.2

uniform dist.

$U = 2$

0.2	0.2	0.2	0.2	0.2

			0.2	

only these 3 can contribute to the prob. of this cell

$$\left.\begin{matrix} 0.2 \times 0.8 \\ 0.2 \times 0.1 \\ 0.2 \times 0.1 \end{matrix}\right\} = 0.2$$

Convolution

Can be written mathematically by: Theorem of Total Prob.

ex.3

1	0	0	0	0

If you do ∞ number of steps → You get Limit distribution or Stationary "

$U = 1$
$U = 1$
⋮
∞

Ans.

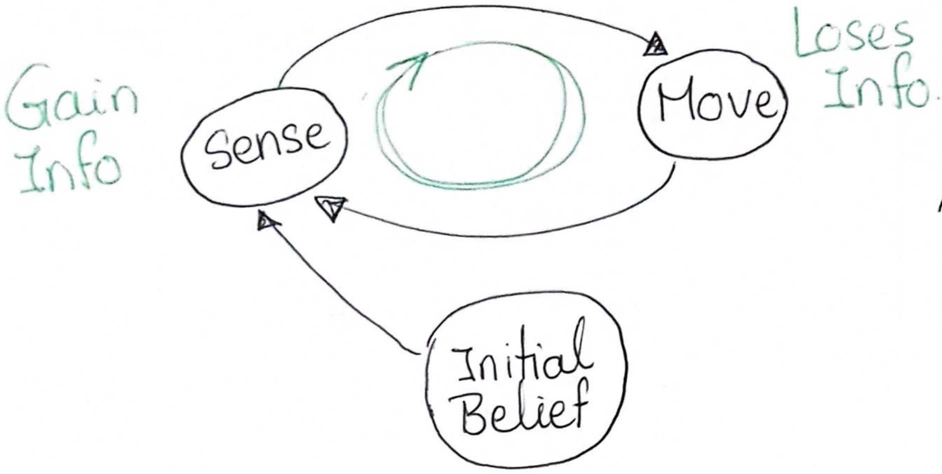
0.2	0.2	0.2	0.2	0.2

→ We get uniform dist., bec. Every time we move we lose info. It has

→ The dist. of the absolute least info is the uniform dist. no preference whatsoever.

$$0.8\, P(X_2) + 0.1\, P(X_3) + 0.1\, P(X_1) = P(X_4)$$

Balance is necessary to define a valid Sol. in the Limit.



A measure of info:
ENTROPY
$\Sigma(-P * \log(P))$

Localization Summary:-

- Belief = Probability

a function over all possible places where a robot might be. & each cell has an associated prob. value.

- Sense = Product, Followed by Normalization

measurement update Func. : is a product, we take prob. values & multiply them up or down depending on the exact measurement.

- Move = Convolution (Addition)

For each possible location after the motion, we reverse engineer the situation and guess where the robot might've come from & then collect it. (we add crossponding probabilities).

Measurements

Bayes Rule

Large if measurement is right & small else

X = grid cell

Z = measurement

(measurement prob.)

chances of seeing Red or green tile for every possible location

non-normalized posterior dist.

$$* \; p(X_i \mid Z) = \frac{\boxed{P(Z \mid X_i) \; P(X_i)}}{P(Z)}$$

prior dist.

Normalization. (doesn't have the grid cell as index, $P(Z)$ is the same for all grid cells)

Seeks to calculate a belief over my location after seeing the measurement

$$* \; p(Z) = \sum_i p(Z \mid X_i) \, P(X_i)$$

$$\bar{p}(X_i \mid Z) \longleftarrow p(Z \mid X_i) \, P(X_i)$$ (Non-normalized prob.)

$$\alpha \longleftarrow \sum \bar{p}(X_i \mid Z)$$ Normalizer

$$p(X_i \mid Z) \longleftarrow \frac{1}{\alpha} \bar{p}(X_i \mid Z)$$

Motion - Total Probability

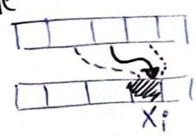
$$P(X_i^t) = \sum_j P(X_j^{t-1}) \cdot P(X_i \mid X_j)$$

time

grid cell

prob. of motion command to move us from $j \to i$

To get posterior prob. of X_i is to go through all possible places from which we could have come, all diff js, multiply by prob. that a transition from $j \to i$ given motion command



$$P(A) = \boxed{\sum_B P(A \mid B) \, P(B)}$$

Thoerom of Total prob.

weighted sum over other variables = convolution.