Introduction to artificial intelligence.
Part 3: Reasoning over time

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1 Convergence of the belief state

Given our two sources of information, the transition model and the sensor model, we can study the convergence of the filter. Those two sources can be tune thanks to parameters p and w with $p \in [0; 1]$ and $w \in [1; 7]$. The convergence of the belief state can be calculated by the entropy:

$$S(\mathcal{X}) = -\sum_i P_i(\mathcal{X}) \log_2 P_i(\mathcal{X})$$

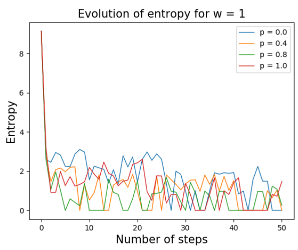
The entropy of probability law is a measure of its dispersion.
If the entropy increase, the system is more ordered, and so, the result is more accurate. In the other hand, if the entropy decrease, the result is less precise.

1.1 What we expect

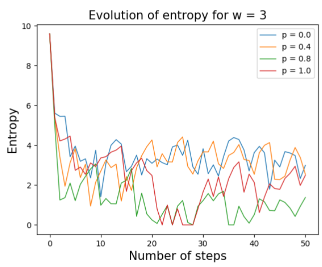
For every case we expect the entropy to decrease fast at the very beginning of the game. Indeed, from a state where each cell of the grid has an equal probability to contain the ghost, the first evidence would give a lot of information, even with a defective sensor.

Our intuition would tell us the more p is high, the more we know about the real behaviour of the ghost and would allow the filter to have a very low entropy (i.e. very few incertitude about its position).
Also we could predict the entropy will be more steady if the sensor is of higher quality.

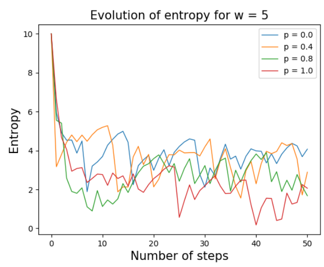
1.2 What we observe



(a) Graph entropy for w = 1



(b) Graph entropy for w = 3



(c) Graph entropy for w = 5

- $w = 1$**:** We can see on this first graph that we obtain something not very logical, we have better results for $p = 0.4$ or $p = 0.8$ than for $p = 1$.
- $w = 3$**:** We see that the entropy is greater than the first graph due to our w. At the same time we observe that the filter tends to present more variation between each p than in the first graph.

- $w = 5$**:** On this graphic, all the prior probability of the ghost to go to the right (p) have the appearance that we were waiting: for $p = 1$ we have the smaller entropy, and for $p = 0$ the biggest entropy. With that, we can confirm that the prior probability has a normal development.

When the quality of the sensor decrease, the entropy also decrease. For a small w, the precision of our senor is better than for a greater w.
We can return in term of convergence: In these three cases, the system converges rapidly, but, for the first one, the convergence is better than the other.

1.3 What we could improve about measurement

Some results might seem incoherent regarding our expectation. However, that can be easily explained because we plot our results based on a single execution for every combination of parameter. Running each combination multiple times to compute the mean and the variance would lead to observe smoother lines. The more p and w are close to 1, the more those lines would tend to reduce their mean and their variance.

2 Improve our agent

To improve our agent we can take into account the walls to calculate our sensor model. We know that if the evidence is given next to a wall or within a wall, the probability to find a ghost on or behind the walls is null. Indeed, in the rows of the sensor matrix, corresponding to a real position of a ghost, we could redistribute all the probabilities situated in illegal positions to the free cells of the map.
For a sensor of quality w, n, the number of illegal positions in the range of the sensor and f, the number of free cells in the radar, the probabilities in the free cells would be $\frac{1}{f}$. (with $(2w+1)^2 = n + f$)

2.1 To sum up

To sum up, we see that the best values of p and w to have the more precisely system (transition model and sensor quality) is to choose, $p = 1$ and $w = 1$. But, in our case, we don't have this result because of our few number of execution. Furthermore, our model is good, but we can improve it the considere external elements, like walls.