Group Assignment: Bayes Filter Assumptions

Group: Aibo

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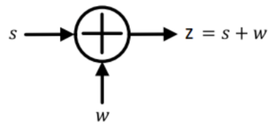
Problem 1

Can you think of an example in which a previous measurement actually interferes with the current one in the real world? Describe a situation under which the measurement independence does not hold.

Solution.

An example of this kind of situation can be if we have an additive noise on measurement, that is depending on the previous values of the noise, i.e., auto-correlated.



Suppose s_t is a function of the state x_t and w_t is the noise. If w_t is depending on w_{t-1}, w_{t-2}, ... and so on, the equality

$$P(z_t|x_t, u_{1:t}, z_{1:t-1}) = P(z_t|x_t)$$

is not holding anymore because also z_t would depend on z_{t-1}, z_{t-2},... and previous.

Example:

If a robot uses sensors like sonar or ultrasound, it might happen that the robot needs to take measurements spontaneously one after another. Moreover, let's suppose that the robot is in a closed room condition. If the room is not echo-proof, then the transmitter will send the signals and it will remain in the room in form of echo. When the robot will measure the next state and if it's not in sufficient intervals, the receiver will have both, the current and previous signal, in echo format which will change the present measurement. As this echo correlates in time we will have time-dependent noise which is a violation of Markov assumption.

Problem 2

Further, find two other examples that show the difficulty of implementing a perfect Bayes filter in a real-world scenario.

Solution.

Example 1

Suppose the robot is estimating the position of the obstacles to plan the trajectory to execute. An unidentified moving obstacle can collide with the robot and change its trajectory. In this case, the belief regarding the state x_t would be incorrect because of the incorrect value of $P(x_t|x_{t-1}, u_t)$. This is also true for unmodeled objects in the map of the environment.

Example 2

The notion of state completeness is mostly of theoretical importance. In practice, it is impossible to specify a complete state for any realistic robot system. For an autonomous car, it should capture the exact position of the ego vehicle on a road together with all other road users like cars, pedestrians (both visible and occluded), their velocities, accelerations, etc. In a robotic manipulation task, this should capture the position and types of all relevant objects as well as the position of the robot itself. For example, if the state is not taking into account sensors' failures, and a sensor is damaged, or the sensor signal is reflected away from the sensor's receiver causing it to return the maximum distance (even if an obstacle exists in the sensor's view). In such scenarios, the correction done with the aid of those measurements, $P(z_t|x_t)$, will lead to incorrect values of the belief.