Insights on the Particle Filtering of the edge service of [1]

As it is explained in section II.A of our submitted paper [1], the MOMCT edge service relies on a Particle Filter (PF) to perform the fusion of tracklets and the trajectory prediction associated to the objects. The trajectory prediction is computed from the weighted average of the set of particles, i.e. $1/N\sum_{i=1}^{N} w^i\mathbf{x}^i$.

This weighted average requires a prediction step and an update step. The **prediction step** obtains the particles at the current time t from the previous time step $t-1$ by means of the next linear transformation:

$$\mathbf{x}_t^i = \mathbf{M}_t\mathbf{x}_{t-1}^i + \mathbf{r}, \tag{1}$$

where $\mathbf{M}$ has the expression:

$$\mathbf{M} = \begin{pmatrix} 1 & \Delta t & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & \Delta t & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix}, \tag{2}$$

$\mathbf{r}$ is a vector that represents the uncertainty in the prediction and $\Delta t = t - t_{-1}$. Usually, the vector $\mathbf{r}$ is adjusted empirically depending on the scenario. In our case, we assume that $\mathbf{r}$ is a normal random noise with 0 mean and standard deviation of 3m. The **update step** obtains the particle's weight at current time step from the one at time step $t-1$, by using the next equation:

$$w_t = w_{t-1} \times \mathcal{L}_{xi}. \tag{3}$$

being $\mathcal{L}_{xi}$ the likelihood function that compares the particle $\mathbf{x}_t^i$ and the incoming tracklet $\mathbf{y}_t$. Where the likelihood function has the next expression assuming normality, and k is the expected variance in the measurement process, which is a parameter to be empirically adjusted.

$$\mathcal{L}_{xi} = \mathcal{N}_{\mathrm{pdf}}\left(\|\mathbf{x}_t^i - \mathbf{y}_t\|, 0, k\right). \tag{4}$$

References

[1] J. Serra, A. Aguilar, E. Abu-Helalah, R. Parada, P. Dini ”Multi-Object Tracking for collision avoidance using multiple cameras in Open RAN Networks” submitted to IEEE ICMLCN 2025.