Road Mapping with a PHD Filter

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Probability hypothesis density filter

- Algorithm for multi-sensor multi-target tracking
- Unknown number of targets,
- Includes both filtering and data association,
- Propagates the posterior intensity, a first order statistical moment of an RFS.

Gaussian Mixture PHD

The posterior intensity

$$v_{k|k}(\mathbf{x}) = \sum_{i=1}^{J_{k|k}} w_{k|k}^{(i)} \mathcal{N}\left(\mathbf{x}; m_{k|k}^{(i)}, P_{k|k}^{(i)}\right)$$

calculated by the PHD filter can be viewed as a **spatial intensity map over the concentration of fixed objects.**

$J_{k|k}$ is the number of Gaussian components,

$w_{k|k}^{(i)}$ is the expected number of objects, described by the spatial density $\mathcal{N}(\mathbf{x}; m_{k|k}^{(i)}, P_{k|k}^{(i)})$.

The multi-target measurement $\mathbf{Z}_k$ received at the radar sensor is given by the union of target generated measurements and clutter.

A random finite set (RFS) is a set with a random number of stochastic states variables

$$\mathbf{X}_k = \left\{\mathbf{x}_k^{(1)}, \ldots, \mathbf{x}_k^{(N_{x,k})}\right\}.$$

Each state represents the position of a stationary point object

$$\mathbf{x}_k^{(i)} = \left[\mathsf{x}^{(i)}\ \mathsf{y}^{(i)}\right]_k^T.$$

Algorithm

Time Update:

$$v_{k+1|k}(\mathbf{x}) = v_{S,k+1|k}(\mathbf{x}) + v_{\beta,k+1|k}(\mathbf{x}) + \gamma_{k+1}(\mathbf{x}),$$

$v_{S,k+1|k}$ is the intensity of the RFS containing the predicted and surviving states.

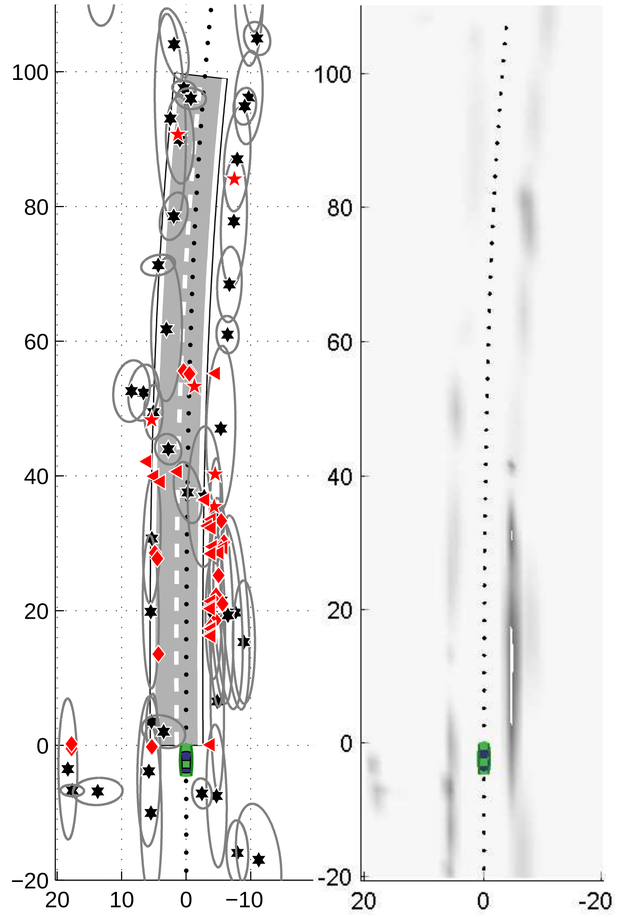
$v_{\beta,k+1|k}$ is the intensity of the RFS spawned by the targets with previous state $\mathbf{x}_{k|k} \in \mathbf{X}_{k|k}$.

γ_{k+1} is the intensity of the birth RFS $\mathbf{\Gamma}_{k+1}$.

Measurement Update:

$$v_{k|k}(\mathbf{x}) = (1 - p_{D,k}) v_{k|k-1}(\mathbf{x}) + \sum_{\mathbf{z} \in \mathbf{Z}_k} v_{D,k|k}(\mathbf{x}|\mathbf{z}).$$

A state $\mathbf{x} \in \mathbf{X}$ is detected with probability p_D. The Gaussian components $\mathcal{N}(m_{k|k}^{(i)}(\mathbf{z}), P_{k|k}^{(i)})$ of the updated intensity $v_{D,k|k}(\mathbf{x}|\mathbf{z})$ are calculated using the UKF.



Gaussian mixture and intensity representation