Detection and Tracking of Moving Target using Track Before Detect (TBD) method

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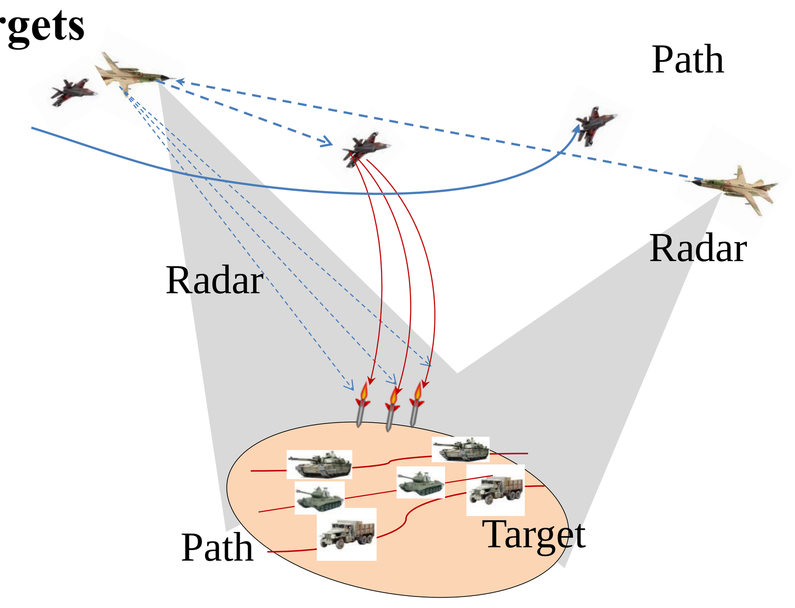
1. Introduction: Context, Problem , motivation and the goal

Context and problem: Detection and Tracking of Moving Stealthy Targets



Target tracking in low SNR

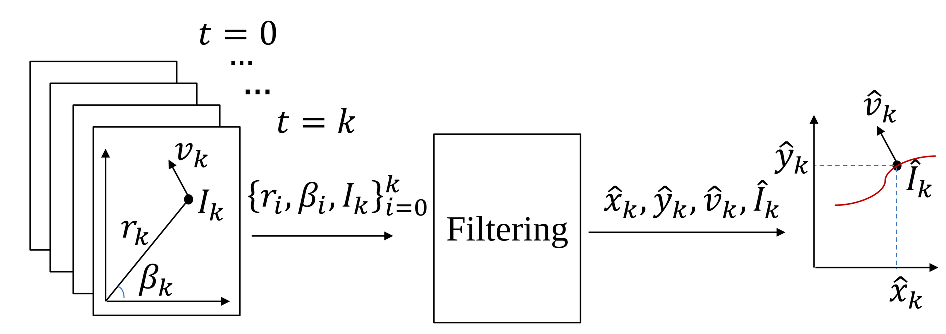
❑Recent developments of stealthy military aircraft and cruise missiles have emphasized the need to detect and track low SNR targets. For this dim targets, there is a considerable advantage in using the unthresholded data for simultaneous detection and track initiation. This concept known as Track-Before-Detect approach,

Motivation:

Track-Before-Detect algorithms incorporate unthresolded measurements to track target under low SNR using particle filter.

The goal:

- To detect and track low SNR targets simultaneously,
- Estimate the position, velocity and intensity of the move object in sequence of image.



An object moves in a two-dimensional space

2. Target Model and Sensor Model

The nonlinear dynamic system is described by :

$$x_{k+1} = f_k(x_k, E_k, v_k)$$
$$z_k = h_k(x_k, E_k, w_k)$$

Target Model:

The state vector : $x_k = [x_k \quad \dot{x}_k \quad y_k \quad \dot{y}_k \quad I_k]^T$

$$x_{k+1} = \begin{cases} f_k(x_k, v_k) & \textit{if target present} \\ undefined & \textit{if target absent} \end{cases}$$

Two state transitional probabilies:

$$P_b \triangleq P\{E_k = 1 | E_{k-1} = 0\}$$
$$P_d \triangleq P\{E_k = 0 | E_{k-1} = 1\}$$

Sensor Model:

Measurement:

$$z_k^{(i,j)} = \begin{cases} h_k^{(i,j)}(x_k) + w_k^{(i,j)} & \textit{if target present} \\ w_k^{(i,j)} & \textit{if target absent} \end{cases}$$

The set of complete measurements:

$$Z_k = \{z_i, i = 1, \dots, k\}$$

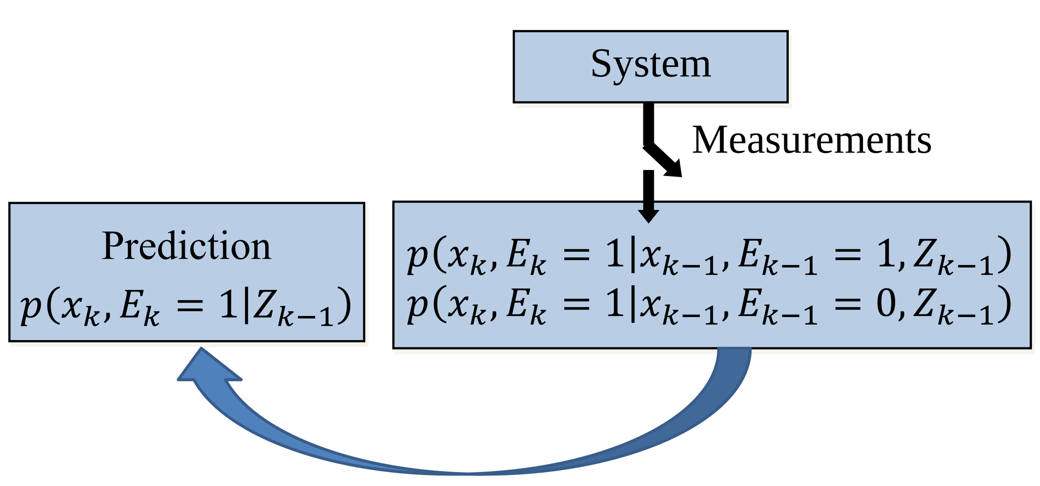
4. Recursive Bayesian Solution

The formal recursive Bayesian can be presented as two step:

Prediction:

If $E_k = 0$ the target state is not defined.

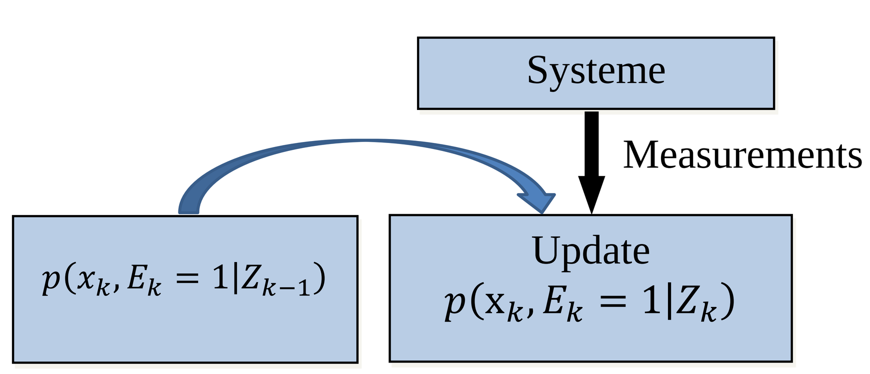
For $E_k = 1$, the prediction step can given by:



Prediction step

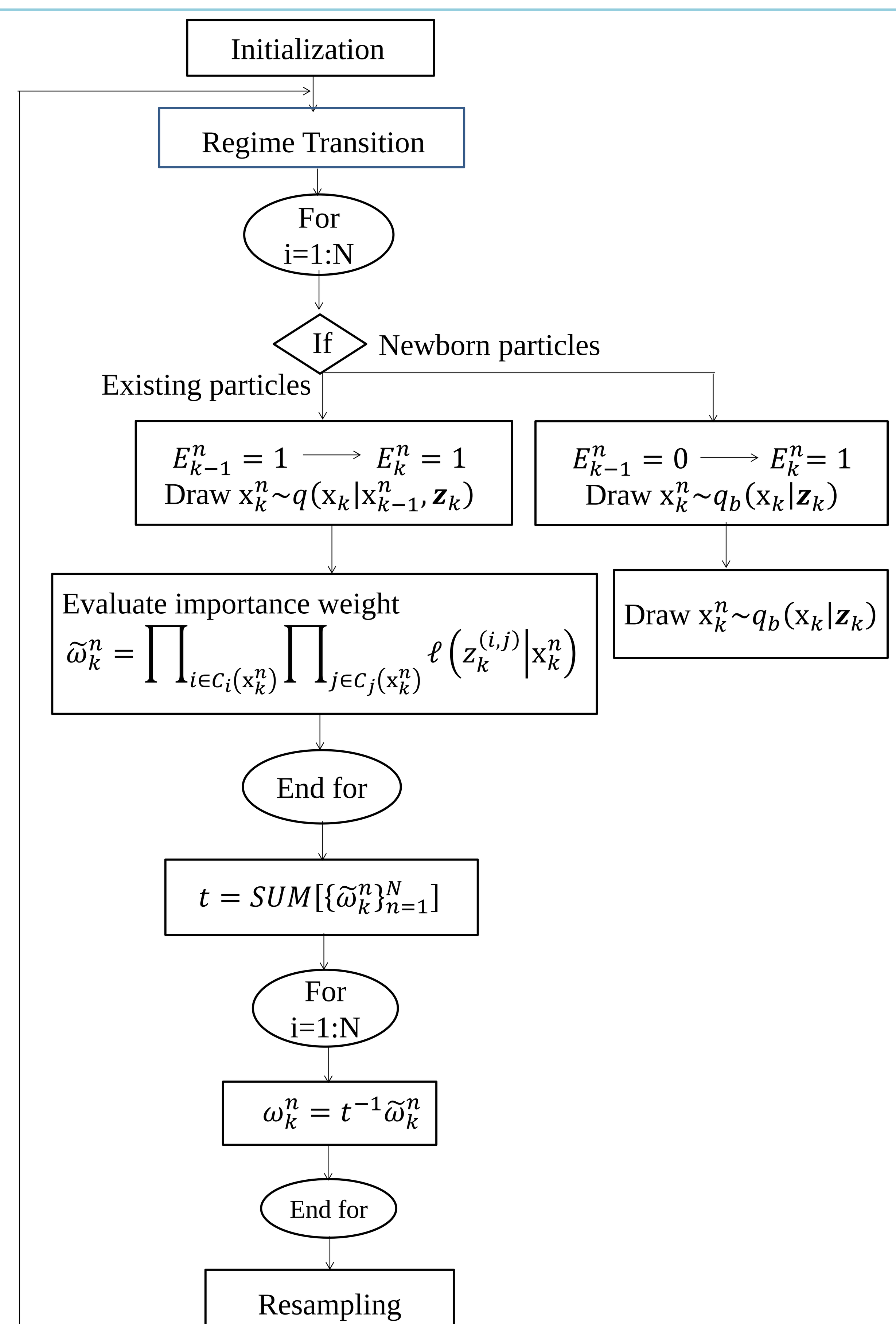
Update:

The update stape in the Bayesian framework is given by:



Update step

4. Particle Filter For TBD (PF-TBD)

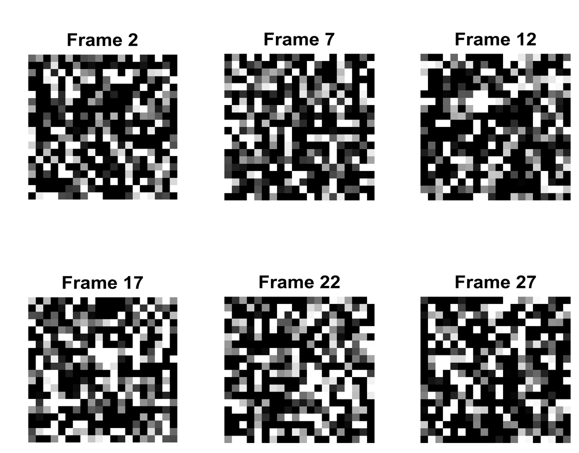


PF-TBD Algorithm

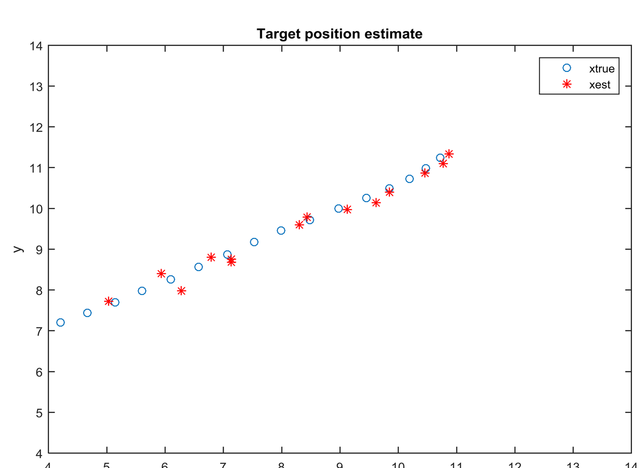
6. Simulation and Results

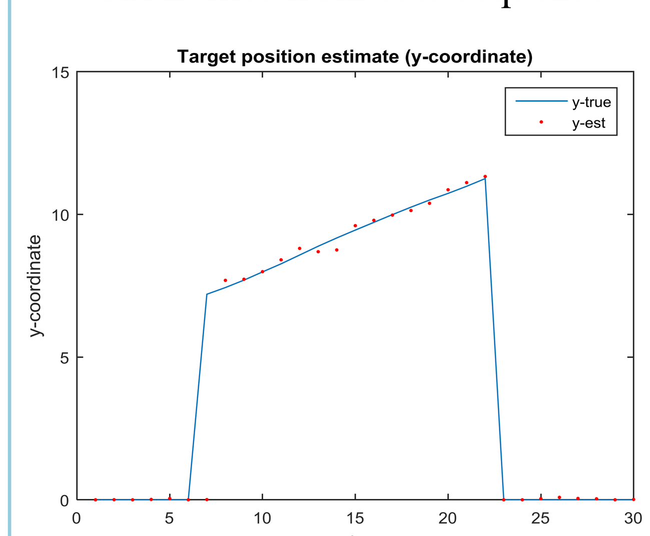
Scenario 1:

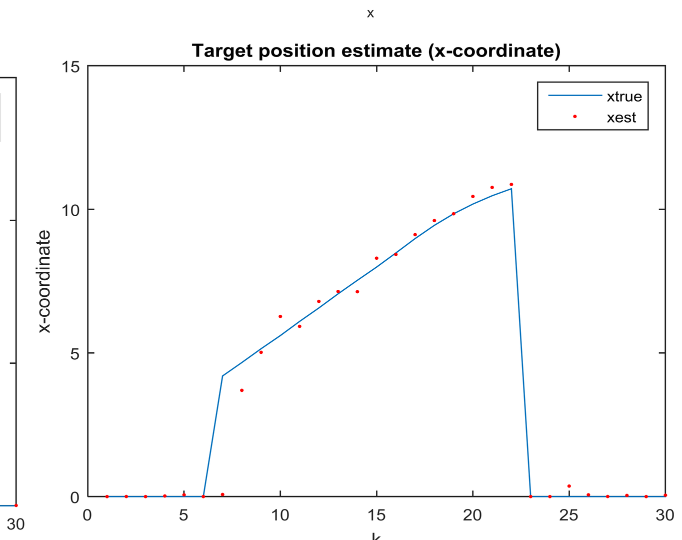
In this scenario, a constant-velocity (CV) model is used :



Six frames from data sequence

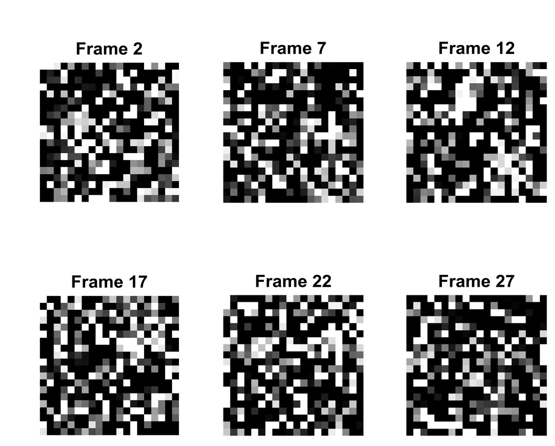




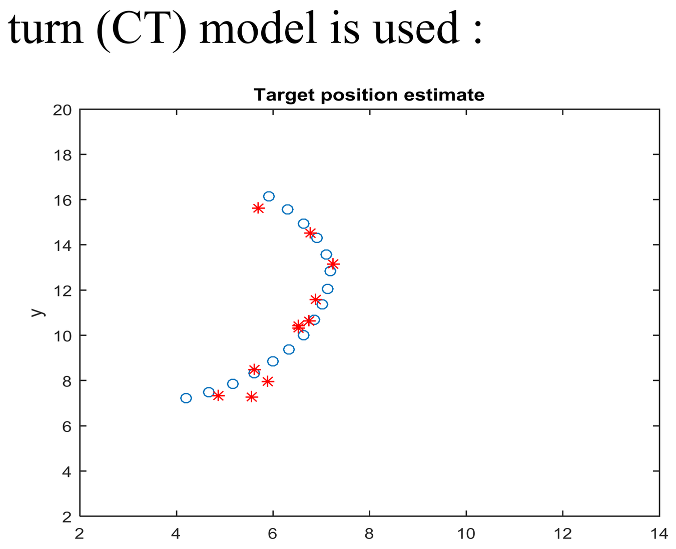


Scenario 2:

In this scenario, a coordinate turn (CT) model is used :



Six frames from data sequence



Conclusion & Perspectives

In this wok The detection and tracking of the performance advantage PF-TBD algorithm have been demonstrated by a low signal-to-noise point target against a background of Gaussian noise with CV and CT motion models.

Perspectives:

- ❑*This method can be extended to multiple targets (for fixed or varying number of targets).*
- ❑*Used for maneuvering target with different motion model.*
- ❑*This method can be extented to multiple sensors target tracking.*

References

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[4] S.P. Ebenezer, A. Papandreou-Suppappola, "Generalized Recursive Track-Before-Detect With Proposal Partitioning for Tracking Varying Number of Multiple Targets in Low SNR",IEEE Trans. Signal Processing 64(11):2819-2834 (2016)