Road Boundary Detection and Tracking Using Monochrome Camera Images

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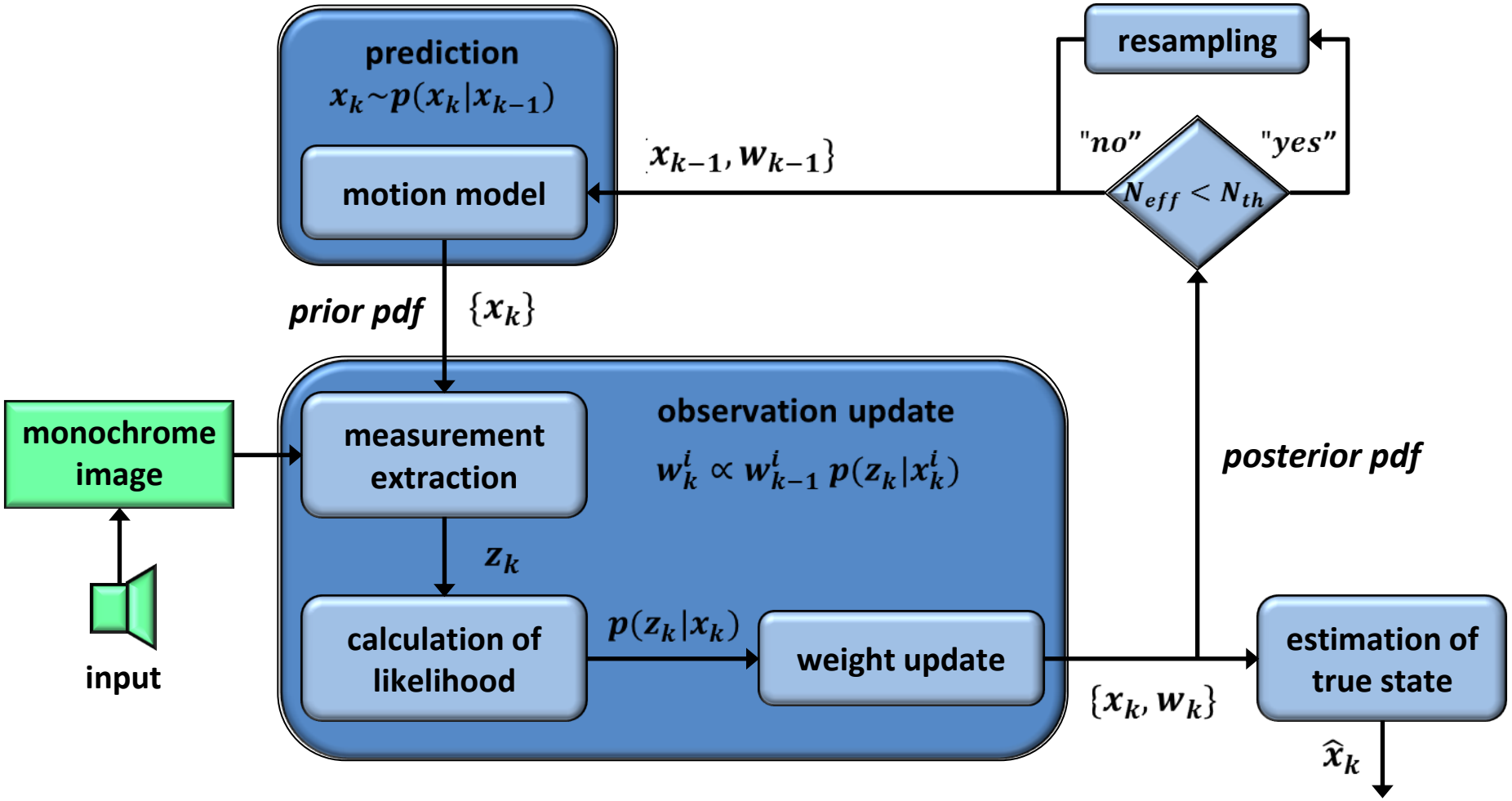
Motivation

- prevention of accidents important task in driver assistance
- many accidents are caused by inattention
- most systems for lane departure warning rely on lane markings
- systems for roads without lane markings still required
  - ➔ development of a system for road boundary detection and tracking
  - ➔ system that is not restricted to roads with lane markings

Particle Filter System - Overview



x_k : samples z_k: measurements
w_k : weights k : time step
N_{eff} : effective sample size

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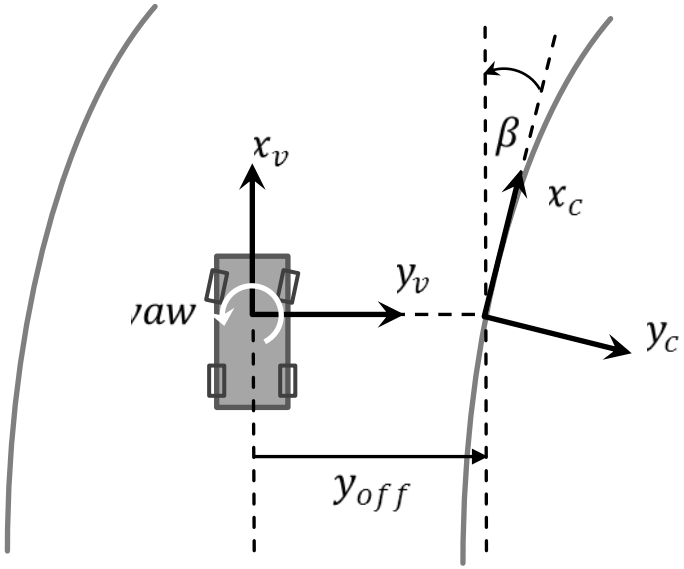
Dynamic System – Clothoid Road Model



$$x_{v,rb}(l) = l$$
$$y_{v,rb}(l) = \frac{1}{6}c_1 l^3 + \frac{1}{2}c_0 l^2 + \beta l + y_{off}$$
$$z_{v,rb}(l) = 0$$

state vector $x = \begin{pmatrix} y_{off} \\ \beta \\ c_0 \\ c_1 \end{pmatrix}$

y_{off} : lateral offset c_0 : initial curvature
β : heading angle c_1 : curvature change rate

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Dynamic System – Motion Model

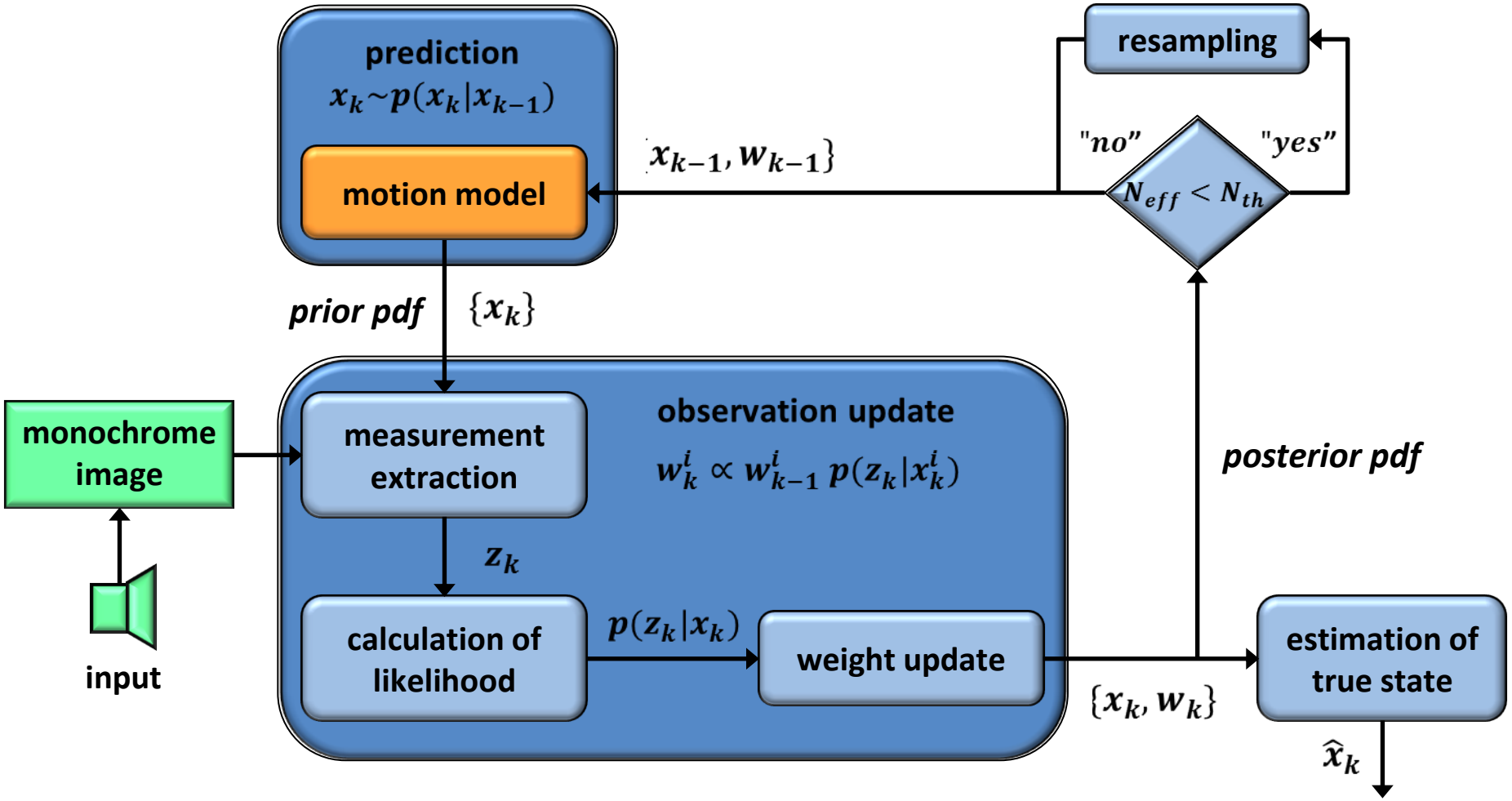
- prediction for small time interval dt
  - ⇨ constant velocity v
  - ⇨ constant yaw-rate $\dot{\psi}$

- vehicle motion: $x(t) = vt \quad \psi(t) = \dot{\psi}t$
  $y(t) = 0$

- relative motion of road boundary:

$$x_k = \begin{pmatrix} 1 & vdt & 0 & \frac{1}{2}(vdt)^2 & \frac{1}{6}(vdt)^3 \\ 0 & 1 & vdt & \frac{1}{2}(vdt)^2 & \frac{1}{6}(vdt)^3 \\ 0 & 0 & 1 & vdt & \frac{1}{2}(vdt)^2 \\ 0 & 0 & 0 & 1 & vdt \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix} x_{k-1} + \begin{pmatrix} 0 \\ 0 \\ dt \\ 0 \\ 0 \end{pmatrix} \dot{\psi}$$

Particle Filter System - Overview



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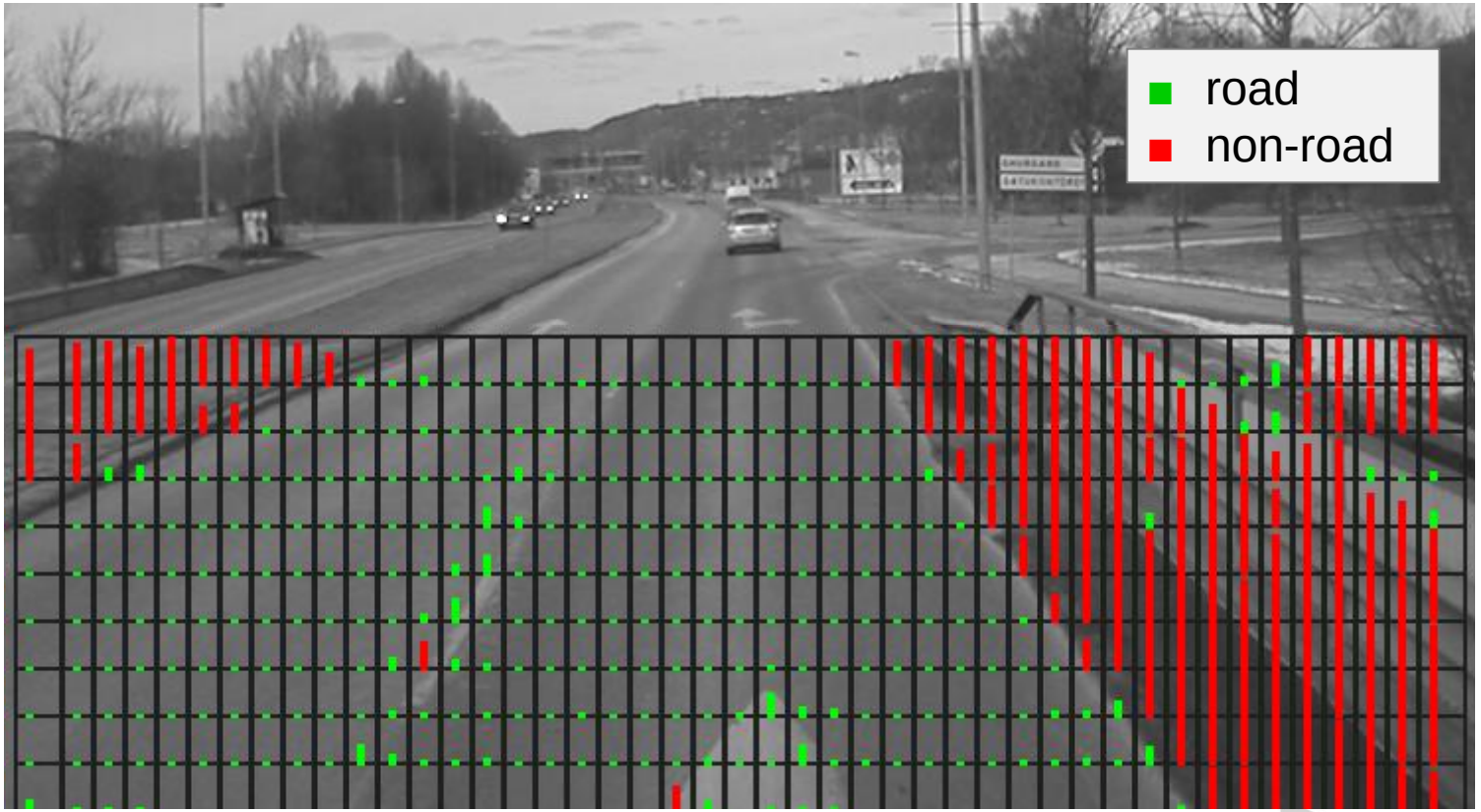
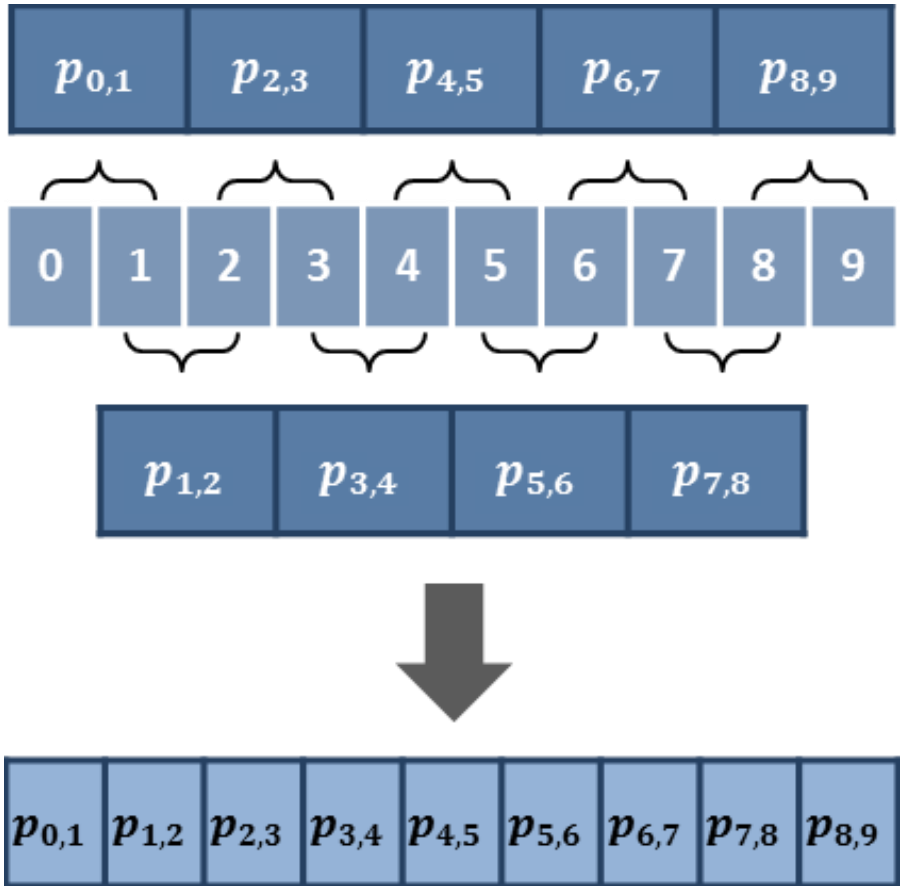
Measurement – Image Classification

- road detection based on texture features
- classifer output $d \in [d_{min}, d_{max}]$
- assignment to “road” and “non-road” class



Measurement – Overlapping

feature extraction regions

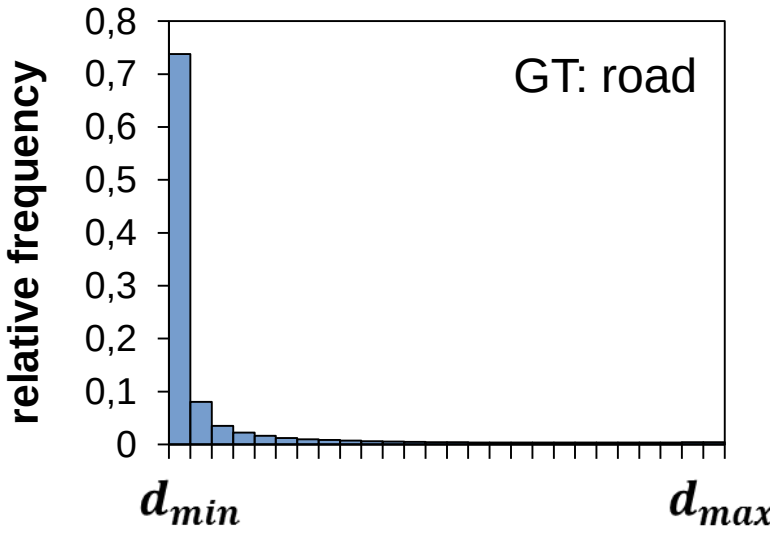


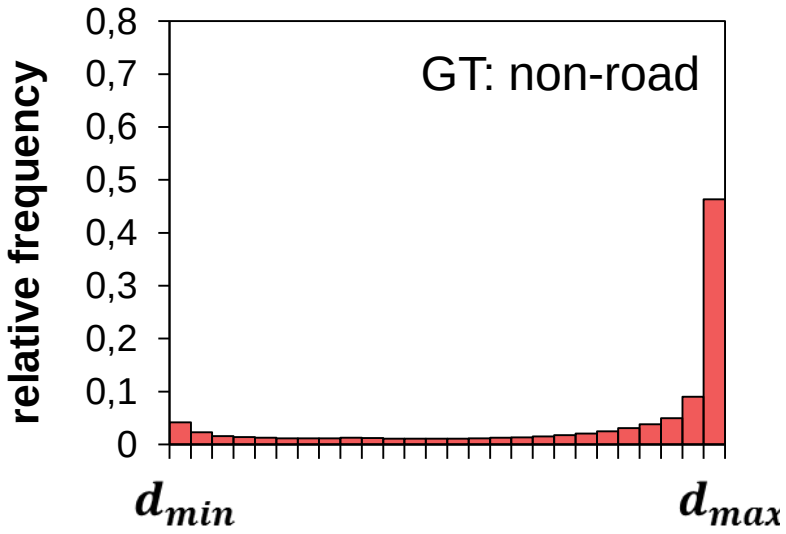
combined feature vectors

combined feature vectors

Measurement – Probability

- empirically determined probability of d
- $d \Rightarrow d_i \in \{d_0, d_1, \ldots, d_{23}, d_{24}\}$





$$p(d_i|road) \approx hist_{road}(d_i)$$
$$p(d_i|non-road) \approx hist_{non-road}(d_i)$$

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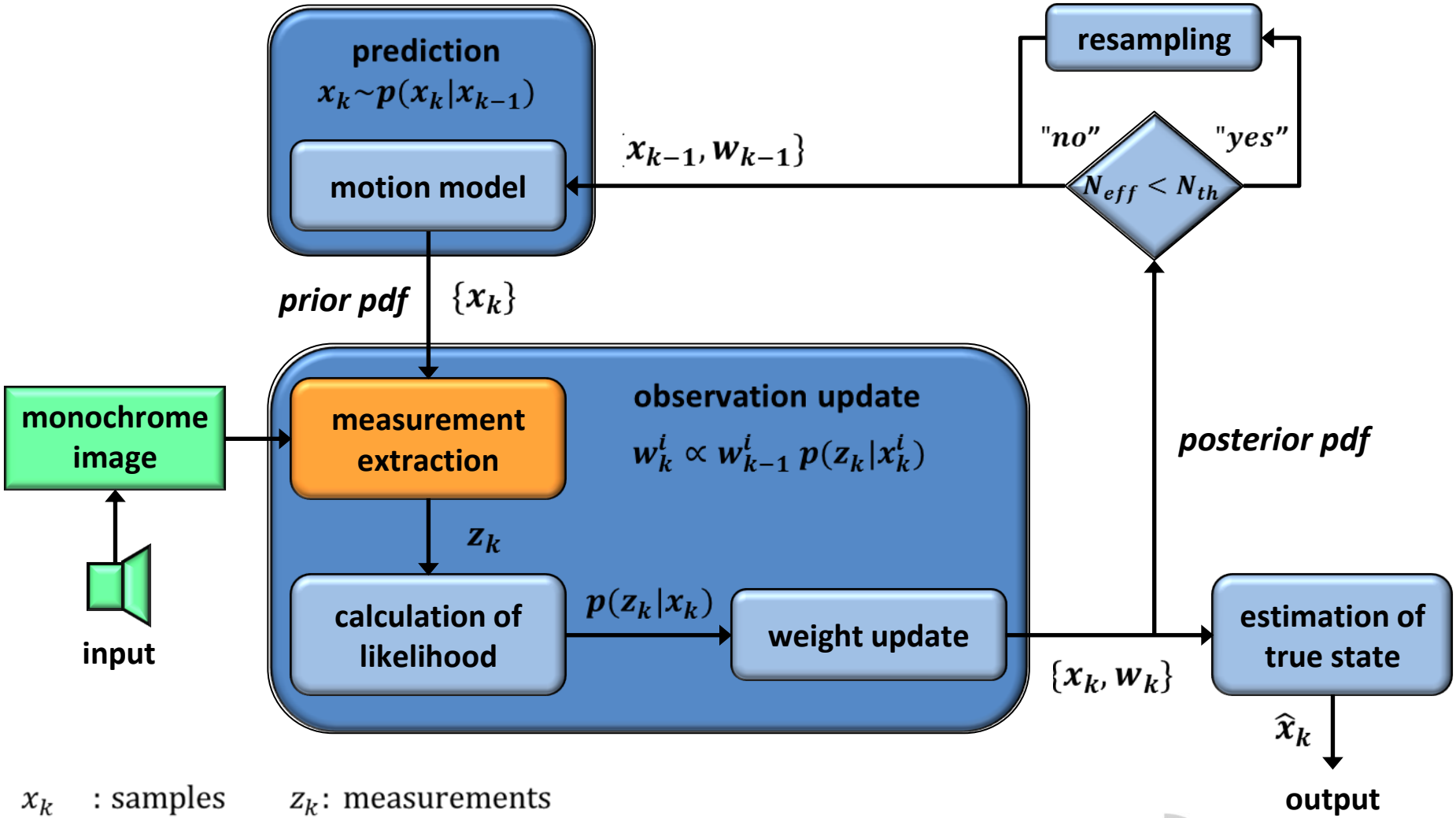
Particle Filter System - Overview



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Likelihood – Calculation (1/2)

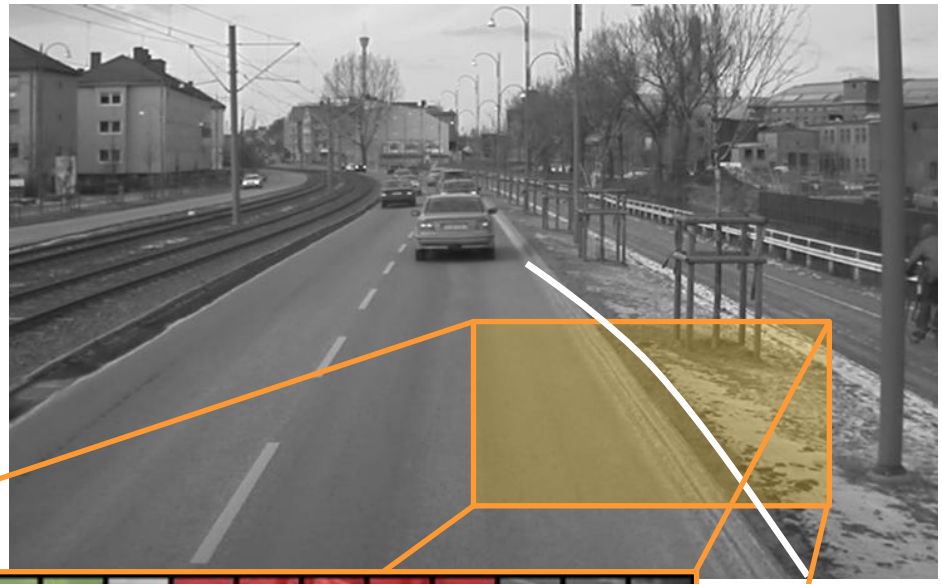
$$p(z_k|x_k^i) = \prod_{m=0}^{N_{row}} p(z_{k,m}|x_k^i)$$

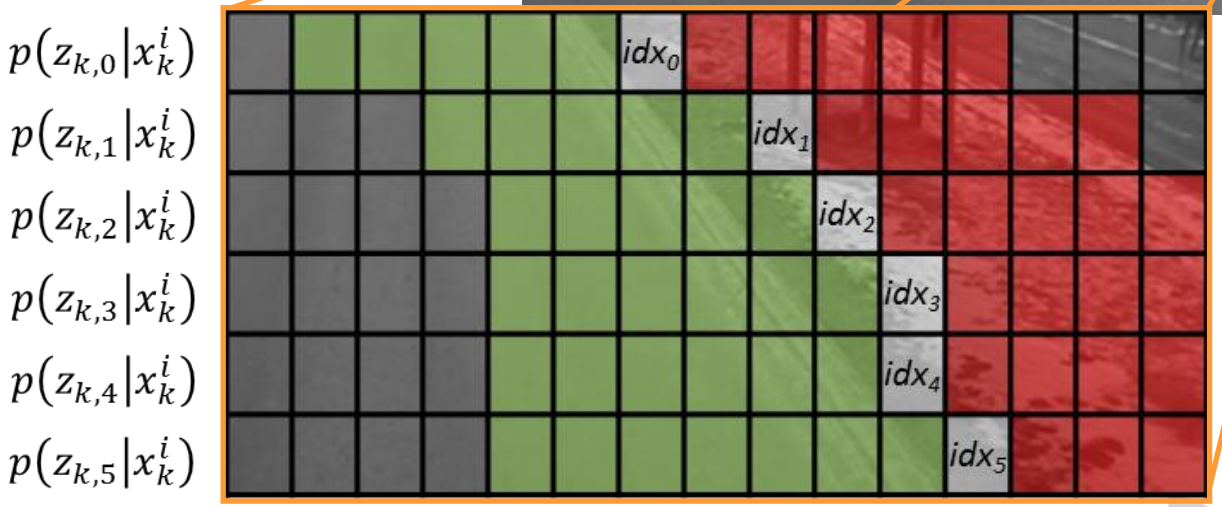
N_{row} : number of rows

m : row index

$z_{k,m}$: measurements in row m

idx_m : horizontal patch position of road boundary in row m





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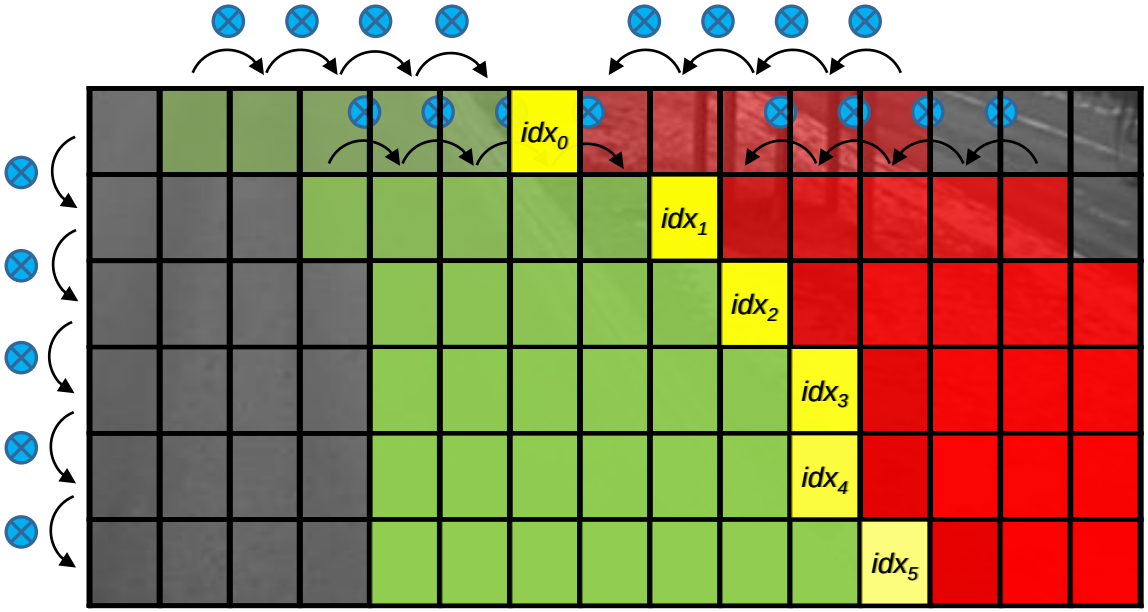
Likelihood – Calculation (2/2)



$$p\left(z_{k,m}\middle|x_k^i\right) = \prod_{j=idx_m\left(x_k^i\right)-N_l}^{idx_m\left(x_k^i\right)-1} p\left(z_{k,m,j}\middle|\text{patch}_j=\text{road}\right) * \prod_{j=idx_m\left(x_k^i\right)+1}^{idx_m\left(x_k^i\right)+N_r} p\left(z_{k,m,j}\middle|\text{patch}_j=\text{non-road}\right)$$

N_l : number of left neighbors $\quad$ j : horizontal position

N_r : number of right neighbors $\quad$ $z_{k,m,j}$: measurement at position (m,j)

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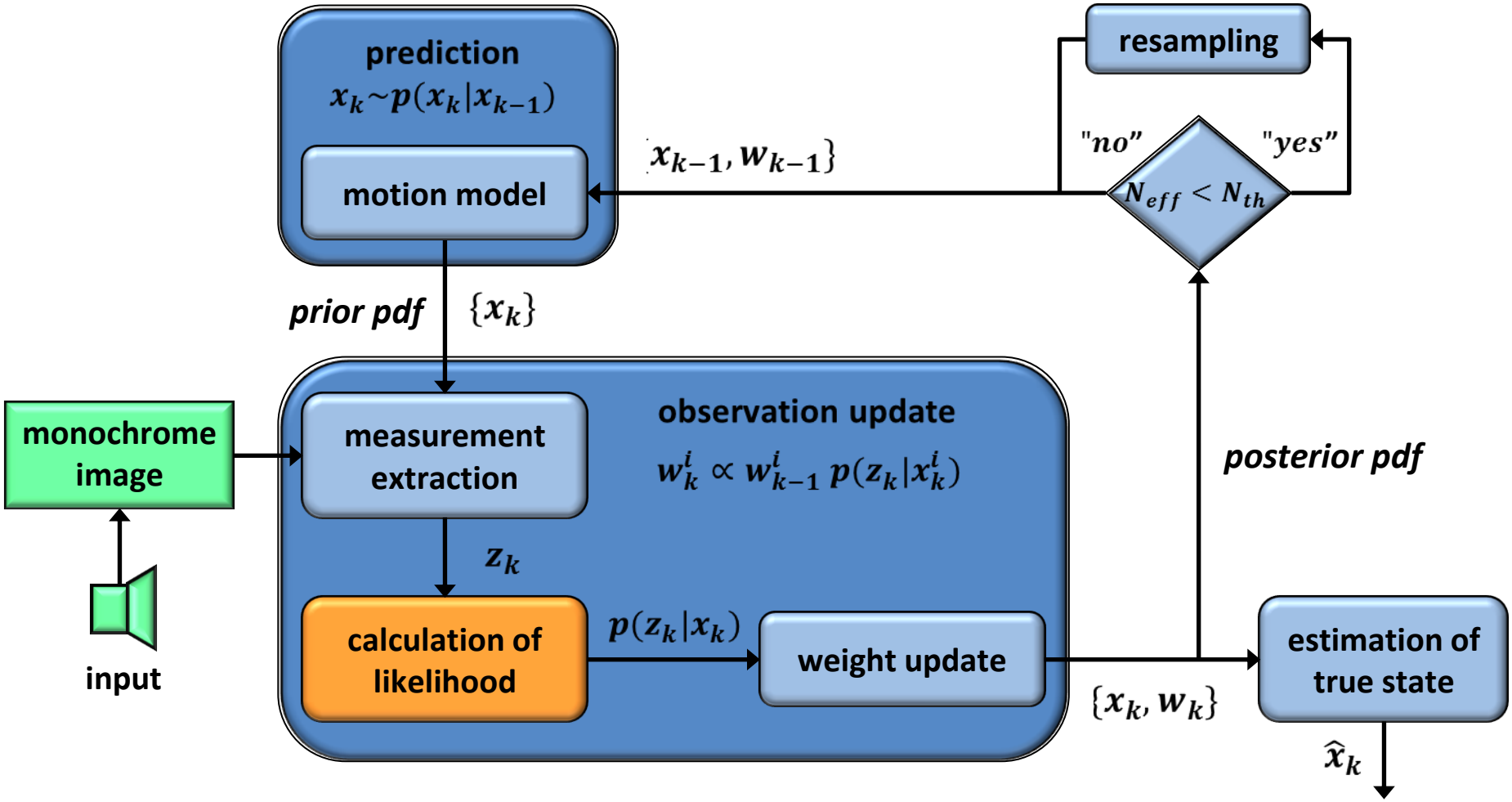

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Results

match-rate	0.7729
RMSE[m]	0.2957

Videos


vel: 23.4 m/s (84 km/h)
yaw: 0.20
looptime: 33 ms
frame: 17629/ 452
time: 52460.15
RADAR: ERROR

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Accident avoidance by active intervention for Intelligent Vehicles

Thank you.

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SEVENTH FRAMEWORK
PROGRAMME

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