BP-based SLAM Algorithm

$q(\boldsymbol{x}_{n-1})$; $\tilde{q}\big(\tilde{\boldsymbol{a}}_{k,n-1}^{(j)},1\big)$ and $\tilde{q}_{k,n-1}^{(j)}$, $k\in\mathcal{K}_{n-1}^{(j)}$, $j\in\{1,\ldots,J\}$ (from previous time step $n-1$)

Prediction:

- Calculate $\alpha(\boldsymbol{x}_n)$ according to (31)
- Calculate $\alpha_k\big(\tilde{\boldsymbol{a}}_{k,n}^{(j)},1\big)$ and $\alpha_{k,n}^{(j)}$, $k\in\mathcal{K}_{n-1}^{(j)}$, $j\in\{1,\ldots,J\}$ according to (33), (34)

$\alpha(\boldsymbol{x}_n)$

Measurement Evaluation:

- (for legacy PFs) Calculate $\beta\big(c_{k,n}^{(j)}\big)$, $k\in\mathcal{K}_{n-1}^{(j)}$, $j\in\{1,\ldots,J\}$ according to (35)
- (for new PFs) Calculate $\xi\big(b_{m,n}^{(j)}\big)$, $m\in\mathcal{M}_n^{(j)}$, $j\in\{1,\ldots,J\}$ according to (36), (37); this requires calculation of $f_{\mathrm{n},n}\big(\boldsymbol{a}_{\cdot,n}^{(j)}\big|\boldsymbol{x}_n\big)$ according to (50) and of $\mu_{\mathrm{n},n}^{(j)}=\int\int P_{\mathrm{d}}^{(j)}\big(\boldsymbol{x}_n,\boldsymbol{a}_{\cdot,n}^{(j)}\big)\,\lambda_{n|n-1}^{\mathrm{u}}\big(\boldsymbol{a}_{\cdot,n}^{(j)}\big)\alpha(\boldsymbol{x}_n)\,\mathrm{d}\boldsymbol{a}_{\cdot,n}^{(j)}\,\mathrm{d}\boldsymbol{x}_n$

$\lambda_{n|n-1}^{\mathrm{u}}\big(\boldsymbol{a}_{\cdot,n}^{(j)}\big)$

Iterative Data Association:

- Calculate $\eta\big(c_{k,n}^{(j)}\big)$, $k\in\mathcal{K}_{n-1}^{(j)}$, $j\in\{1,\ldots,J\}$ and $\varsigma\big(b_{m,n}^{(j)}\big)$, $m\in\mathcal{M}_n^{(j)}$, $j\in\{1,\ldots,J\}$ according to (38)–(40)

Measurement Update:

- (for agent) Calculate $\gamma_k^{(j)}(\boldsymbol{x}_n)$, $k\in\mathcal{K}_{n-1}^{(j)}$, $j\in\{1,\ldots,J\}$ according to (41)
- (for legacy PFs) Calculate $\gamma\big(\tilde{\boldsymbol{a}}_{k,n}^{(j)},1\big)$ and $\gamma_{k,n}^{(j)}$, $k\in\mathcal{K}_{n-1}^{(j)}$, $j\in\{1,\ldots,J\}$ according to (42), (43)
- (for new PFs) Calculate $\phi\big(\breve{\boldsymbol{a}}_{m,n}^{(j)},1\big)$ and $\phi_{m,n}^{(j)}$, $m\in\mathcal{M}_n^{(j)}$, $j\in\{1,\ldots,J\}$ according to (44), (45)

Belief Calculation:

- (for agent) Calculate $q(\boldsymbol{x}_n)$ according to (46)
- (for legacy PFs) Calculate $\tilde{q}\big(\tilde{\boldsymbol{a}}_{k,n}^{(j)},1\big)$ and $\tilde{q}_{k,n}^{(j)}$, $k\in\mathcal{K}_{n-1}^{(j)}$, $j\in\{1,\ldots,J\}$ according to (47)
- (for new PFs) Calculate $\breve{q}\big(\breve{\boldsymbol{a}}_{m,n}^{(j)},1\big)$, and $\breve{q}_{m,n}^{(j)}$, $m\in\mathcal{M}_n^{(j)}$, $j\in\{1,\ldots,J\}$ according to (48)

Pruning:

- Determine set $\tilde{\mathcal{K}}_n^{(j)}=\mathcal{K}_{n-1}^{(j)}\cup\mathcal{M}_n^{(j)}$
- For all $j\in\{1,\ldots,J\}$, reinterpret/reindex beliefs $\tilde{q}\big(\tilde{\boldsymbol{a}}_{k',n}^{(j)},1\big)$ and $\tilde{q}_{k',n}^{(j)}$ $\big(k'\in\tilde{\mathcal{K}}_{n-1}^{(j)}\big)$ and beliefs $\breve{q}\big(\breve{\boldsymbol{a}}_{m,n}^{(j)},1\big)$ and $\breve{q}_{m,n}^{(j)}$ $\big(m\in\mathcal{M}_n^{(j)}\big)$ as beliefs $\tilde{q}\big(\tilde{\boldsymbol{a}}_{k,n}^{(j)},1\big)$ and $\tilde{q}_{k,n}^{(j)}$ of legacy PFs $k\in\tilde{\mathcal{K}}_n^{(j)}$
- For all $j\in\{1,\ldots,J\}$, calculate estimates $\hat{p}\big(r_{k,n}^{(j)}=1\big|\boldsymbol{z}_{1:n}\big)$ of existence probabilities $p\big(r_{k,n}^{(j)}=1\big|\boldsymbol{z}_{1:n}\big)$, $k\in\tilde{\mathcal{K}}_n^{(j)}$ according to (28) with $f\big(\boldsymbol{a}_{k,n}^{(j)},r_{k,n}^{(j)}=1\big|\boldsymbol{z}_{1:n}\big)$ replaced by $\tilde{q}\big(\tilde{\boldsymbol{a}}_{k,n}^{(j)},1\big)$ or $\breve{q}\big(\breve{\boldsymbol{a}}_{m,n}^{(j)},1\big)$
- For all $j\in\{1,\ldots,J\}$, determine set $\mathcal{K}_n^{(j)}$ of legacy PFs k for which $\hat{p}\big(r_{k,n}^{(j)}=1\big|\boldsymbol{z}_{1:n}\big)>P_{\text{prun}}$

$q(\boldsymbol{x}_n)$; $\hat{p}\big(r_{k,n}^{(j)}=1\big|\boldsymbol{z}_{1:n}\big)$, $k\in\mathcal{K}_n^{(j)}$, $j\in\{1,\ldots,J\}$

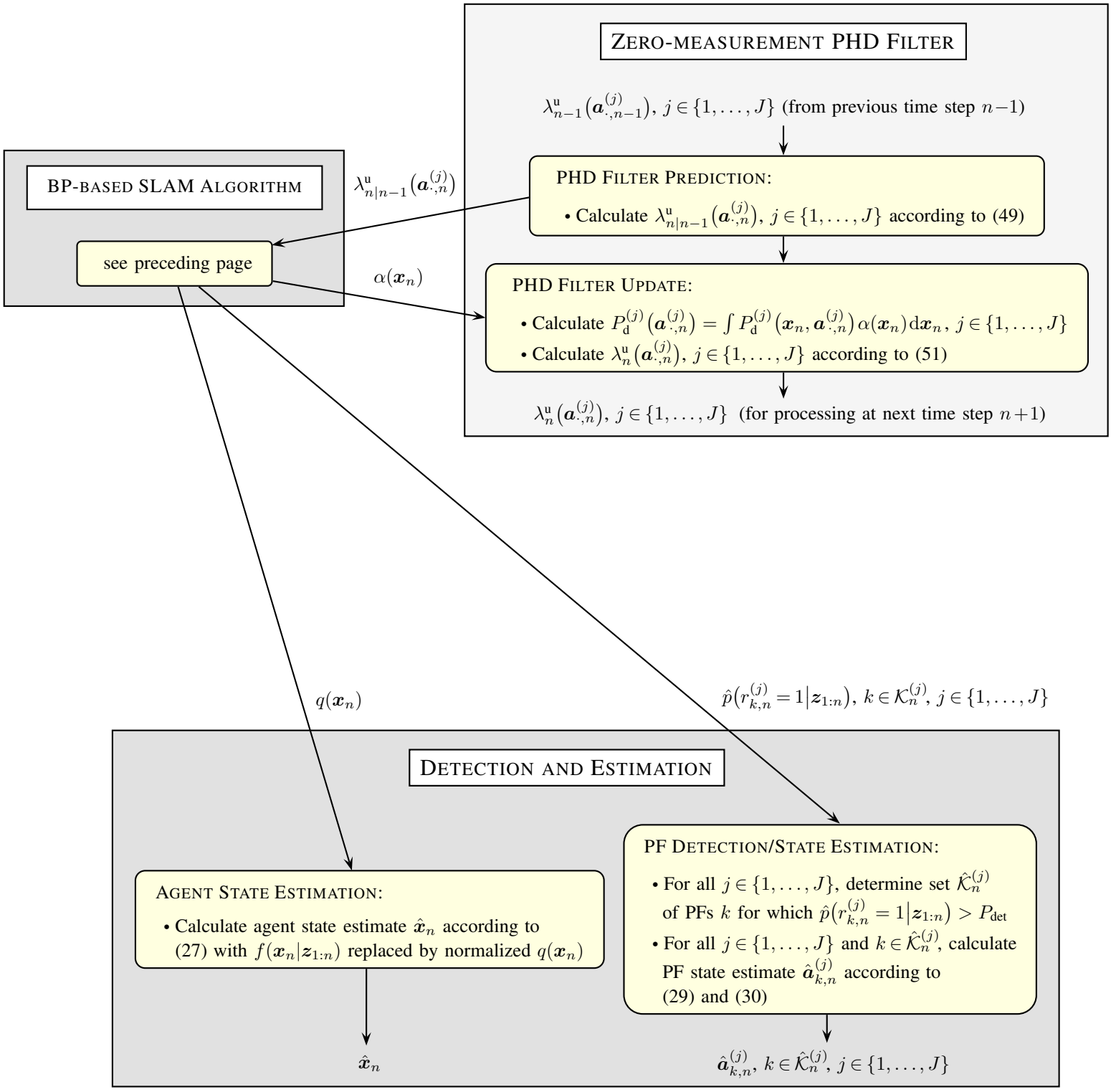
$q(\boldsymbol{x}_n)$; $\tilde{q}\big(\tilde{\boldsymbol{a}}_{k,n}^{(j)},1\big)$ and $\tilde{q}_{k,n}^{(j)}$, $k\in\mathcal{K}_n^{(j)}$, $j\in\{1,\ldots,J\}$
(for processing at next time step $n+1$)

Zero-measurement PHD Filter

see next page

Detection and Estimation

see next page


ZERO-MEASUREMENT PHD FILTER
$\lambda^{\mathrm{u}}_{n-1}(\boldsymbol{a}^{(j)}_{\cdot,n-1})$, $j \in \{1,\ldots,J\}$ (from previous time step $n-1$)
PHD FILTER PREDICTION:
• Calculate $\lambda^{\mathrm{u}}_{n|n-1}(\boldsymbol{a}^{(j)}_{\cdot,n})$, $j \in \{1,\ldots,J\}$ according to (49)
PHD FILTER UPDATE:
• Calculate $P^{(j)}_{\mathrm{d}}(\boldsymbol{a}^{(j)}_{\cdot,n}) = \int P^{(j)}_{\mathrm{d}}(\boldsymbol{x}_n, \boldsymbol{a}^{(j)}_{\cdot,n})\,\alpha(\boldsymbol{x}_n)\,\mathrm{d}\boldsymbol{x}_n$, $j \in \{1,\ldots,J\}$
• Calculate $\lambda^{\mathrm{u}}_{n}(\boldsymbol{a}^{(j)}_{\cdot,n})$, $j \in \{1,\ldots,J\}$ according to (51)
$\lambda^{\mathrm{u}}_{n}(\boldsymbol{a}^{(j)}_{\cdot,n})$, $j \in \{1,\ldots,J\}$ (for processing at next time step $n+1$)
BP-BASED SLAM ALGORITHM
see preceding page
$\lambda^{\mathrm{u}}_{n|n-1}(\boldsymbol{a}^{(j)}_{\cdot,n})$
$\alpha(\boldsymbol{x}_n)$
$q(\boldsymbol{x}_n)$
$\hat{p}(r^{(j)}_{k,n} = 1 | \boldsymbol{z}_{1:n})$, $k \in \mathcal{K}^{(j)}_n$, $j \in \{1,\ldots,J\}$
DETECTION AND ESTIMATION
AGENT STATE ESTIMATION:
• Calculate agent state estimate $\hat{\boldsymbol{x}}_n$ according to (27) with $f(\boldsymbol{x}_n|\boldsymbol{z}_{1:n})$ replaced by normalized $q(\boldsymbol{x}_n)$
PF DETECTION/STATE ESTIMATION:
• For all $j \in \{1,\ldots,J\}$, determine set $\hat{\mathcal{K}}^{(j)}_n$ of PFs k for which $\hat{p}(r^{(j)}_{k,n} = 1 | \boldsymbol{z}_{1:n}) > P_{\mathrm{det}}$
• For all $j \in \{1,\ldots,J\}$ and $k \in \hat{\mathcal{K}}^{(j)}_n$, calculate PF state estimate $\hat{\boldsymbol{a}}^{(j)}_{k,n}$ according to (29) and (30)
$\hat{\boldsymbol{x}}_n$
$\hat{\boldsymbol{a}}^{(j)}_{k,n}$, $k \in \hat{\mathcal{K}}^{(j)}_n$, $j \in \{1,\ldots,J\}$