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**Algorithm 19.4 The incremental EM algorithm for network with table-CPDs**


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Procedure Incremental-E-Step (
   $\theta$ , // Parameters for update
   $m$ , // instance to update
)
1 Run inference on  $\langle \mathcal{G}, \theta \rangle$  using evidence  $\mathcal{O}[m]$ 
2 for each  $i = 1, \dots, n$ 
3   for each  $x_i, \mathbf{u}_i \in \text{Val}(X_i, \text{Pa}_{X_i}^{\mathcal{G}})$ 
4     // Remove old contribution
5      $\bar{M}[x_i, \mathbf{u}_i] \leftarrow \bar{M}[x_i, \mathbf{u}_i] - \bar{M}_m[x_i, \mathbf{u}_i]$ 
6     // Compute new contribution
7      $\bar{M}_m[x_i, \mathbf{u}_i] \leftarrow P(x_i, \mathbf{u}_i \mid \mathcal{O}[m])$ 
8      $\bar{M}[x_i, \mathbf{u}_i] \leftarrow \bar{M}[x_i, \mathbf{u}_i] + \bar{M}_m[x_i, \mathbf{u}_i]$ 

Procedure Incremental-EM (
   $\mathcal{G}$ , // Bayesian network structure over  $X_1, \dots, X_n$ 
   $\theta^0$ , // Initial set of parameters for  $\mathcal{G}$ 
   $\mathcal{D}$  // Partially observed data set
)
1 for each  $i = 1, \dots, n$ 
2   for each  $x_i, \mathbf{u}_i \in \text{Val}(X_i, \text{Pa}_{X_i}^{\mathcal{G}})$ 
3      $\bar{M}[x_i, \mathbf{u}_i] \leftarrow 0$ 
4     for each  $m = 1 \dots M$ 
5        $\bar{M}_m[x_i, \mathbf{u}_i] \leftarrow 0$ 
6     // Initialize the expected sufficient statistics
7   for each  $m = 1 \dots M$ 
8     Incremental-E-Step( $\mathcal{G}, \theta^0, \mathcal{D}, m$ )
9    $m \leftarrow 1$ 
10  for each  $t = 0, 1 \dots$ , until convergence
11    // E-step
12    Incremental-E-Step( $\mathcal{G}, \theta^t, \mathcal{D}, m$ )
13     $m \leftarrow (m \bmod M) + 1$ 
14    // M-step
15    for each  $i = 1, \dots, n$ 
16      for each  $x_i, \mathbf{u}_i \in \text{Val}(X_i, \text{Pa}_{X_i}^{\mathcal{G}})$ 
17         $\theta_{x_i|\mathbf{u}_i}^{t+1} \leftarrow \frac{\bar{M}[x_i, \mathbf{u}_i]}{\bar{M}[\mathbf{u}_i]}$ 
18  return  $\theta^t$ 

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