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**Algorithm 3.1 Algorithm for finding nodes reachable from  $X$  given  $Z$  via active trails**

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Procedure Reachable (
     $\mathcal{G}$ ,    // Bayesian network graph
     $X$ ,      // Source variable
     $Z$       // Observations
)
1    // Phase I: Insert all ancestors of  $Z$  into  $A$ 
2     $L \leftarrow Z$     // Nodes to be visited
3     $A \leftarrow \emptyset$  // Ancestors of  $Z$ 
4    while  $L \neq \emptyset$ 
5        Select some  $Y$  from  $L$ 
6         $L \leftarrow L - \{Y\}$ 
7        if  $Y \notin A$  then
8             $L \leftarrow L \cup \text{Pa}_Y$     //  $Y$ 's parents need to be visited
9             $A \leftarrow A \cup \{Y\}$     //  $Y$  is ancestor of evidence
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11    // Phase II: traverse active trails starting from  $X$ 
12     $L \leftarrow \{(X, \uparrow)\}$     // (Node,direction) to be visited
13     $V \leftarrow \emptyset$     // (Node,direction) marked as visited
14     $R \leftarrow \emptyset$     // Nodes reachable via active trail
15    while  $L \neq \emptyset$ 
16        Select some  $(Y, d)$  from  $L$ 
17         $L \leftarrow L - \{(Y, d)\}$ 
18        if  $(Y, d) \notin V$  then
19            if  $Y \notin Z$  then
20                 $R \leftarrow R \cup \{Y\}$     //  $Y$  is reachable
21                 $V \leftarrow V \cup \{(Y, d)\}$     // Mark  $(Y, d)$  as visited
22                if  $d = \uparrow$  and  $Y \notin Z$  then    // Trail up through  $Y$  active if  $Y$  not in  $Z$ 
23                    for each  $Z \in \text{Pa}_Y$ 
24                         $L \leftarrow L \cup \{(Z, \uparrow)\}$     //  $Y$ 's parents to be visited from bottom
25                    for each  $Z \in \text{Ch}_Y$ 
26                         $L \leftarrow L \cup \{(Z, \downarrow)\}$     //  $Y$ 's children to be visited from top
27                else if  $d = \downarrow$  then    // Trails down through  $Y$ 
28                    if  $Y \notin Z$  then
29                        // Downward trails to  $Y$ 's children are active
30                        for each  $Z \in \text{Ch}_Y$ 
31                             $L \leftarrow L \cup \{(Z, \downarrow)\}$     //  $Y$ 's children to be visited from top
32                    if  $Y \in A$  then    // v-structure trails are active
33                        for each  $Z \in \text{Pa}_Y$ 
34                             $L \leftarrow L \cup \{(Z, \uparrow)\}$     //  $Y$ 's parents to be visited from bottom
35    return  $R$ 
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