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Conceptual Paper

Decomposition Algorithms of Blocking the Selected Edges in the Digraph

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Abstract

In this paper, a protein network represented by a directed graph is considered. The problem of determining the minimum number of edges that break paths from the input proteins of the network to the output ones and passing through some subset of proteins in this network is analyzing. A decomposition algorithms are basing on a selection of classes of cyclically equivalent nodes in the sub-graphs with dedicated subset of nodes is suggesting.

Keywords: Cluster; Digraph; Sub-graph; Protein network; Connectivity component

Concept

By analogy with [1], we consider a protein network represented by a directed graph (digraph) G with the set U of nodes, which are proteins and whose directed edges are paired bonds between nodes represented in the Cytoscape program. Dedicate the subset $U^{/} \subseteq U$ of nodes and decrease in a comparison with [1] a number of edges, which block all paths from outside of the set $U^{/}$ outside of the set $U^{/}$.

Take all nodes from the subset $U^{/}$ and all edges between them. These nodes and edges create directed sub-graph $G^{/} \subseteq G$. Replace all (directed) edges of the sub-graph $G^{/}$ by undirected ones and obtain undirected graph $G^{//}$. Define in the sub-graph $G^{//}$ all its connectivity components $G^{//}{}_1,\dots,G^{//}{}_n$. Return directions to all edges of the sub-graph $G^{//}{}_k$ and define in such a way the sub-graph G_k of the digraph $G, k=1,\dots,n$.

Factorize each sub-graph G_k by a relation of cyclic equivalence (two nodes are cyclically equivalent if there is a cycle containing both of them) and construct acyclic digraph with nodes - clusters of cyclic equivalence. Construct the partial order $\geq$ between the clusters (a relation $A \geq B$ is true if there is a way from cluster A to cluster B) in G_k.

Denote by V_k^{*} a set of edges incoming to G_k and by V_k^{**} a set of edges out-coming from G_k and designate by p_k, q_k numbers of edges in these sets. Define the following sets W_k^{*}, W_k^{**} of clusters $G_{k,i} \in W_k, i=1,\dots,m_k$, in digraph G_k. Each cluster $G_{k,i} \in W_k^{**}$ has final nodes of some edges from the set V_k^{*}. Similarly, each cluster $G_{k,i} \in W_k^{**}$ has initial nodes of some edges from the set V_k^{**}. The sets W_k^{*}, W_k^{**} may intersect.

Construct the set $\overline{W}_k^{*}$, consisting of clusters $G_{k,i}$, such that $G_{k,i} \in W_k^{**}$ or $G_{k,i} \notin W_k^{**}$, but there are some cluster $G_{k,j} \in W_k^{**}$ and a way from $G_{k,i}$ to $G_{k,j}$ in digraph G_k. By analogy construct the set $\overline{W}_k^{**}$ of clusters $G_{k,i}$, such that $G_{k,i} \in W_k^{*}$ or $G_{k,i} \notin W_k^{*}$, but there are some cluster $G_{k,j} \in W_k^{*}$ and a way from $G_{k,j}$ to $G_{k,i}$ in digraph G_k.

Designate by $\overline{V}_k^{*}$ all edges incoming some clusters containing in the set $\overline{W}_k^{*}$ from the outside of the graph G_k (by $\overline{V}_k^{**}$ all edges out-coming from some clusters in the set $\overline{W}_k^{**}$ outside the graph G_k). Denote $\overline{p}_k \leq p_k$ a number of edges in the set $\overline{V}_k^{*}$ (denote $\overline{q}_k \leq q_k$ a number of edges in the set $\overline{V}_k^{**}$).

Assume that $\overline{p}_k \leq \overline{q}_k$ (assume that $\overline{q}_k \leq \overline{p}_k$) and block all edges from $\overline{V}_k^{**}$ (all edges from $\overline{V}_k^{*}$). In such a way, we block all paths from the outside of G_k outside G_k. Then a number of edges blocking the sub-graph G_k equals' $\overline{r}_k = \min(\overline{p}_k, \overline{q}_k) \leq \min(p_k, q_k) = r_k, k=1,\dots,n$. Last inequalities show, how this algorithm decreases a number of blocked edges in a comparison with [1]. Next step of the decomposition procedure in this algorithm may be an allocation of disconnected subsets in pairs of sets $W_k^{*}, W_k^{**}, k = 1, \ldots, n.$

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Conflict of Interest

No conflict of interest.

References

1. G Sh Tsitsiashvili (2019) Improved algorithm of blocking the selected nodes in the digraph, Annals of Biostatistics and Biometric Applications 3(3).