Closed Pattern Mining in Strongly Accessible Set Systems
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given finite set \( E \),

- membership oracle \( M_F: 2^E \rightarrow \{0,1\} \) (defining \( F \subseteq 2^E \)),
- closure operator \( \rho: F \rightarrow F \),

list the family of \( \rho \)-closed sets \( \rho(F) = \{C \in F: C = \rho(C)\} \)

Example:

street network: graph \( G \)

transaction database \( D \): subsets of \( E(G) \)

- \( E \): edge set \( E(G) \)
- \( F \): \( \{X \subseteq E(G) : X \text{ is freq. and connected}\} \)
- \( \rho \): \( X \mapsto \text{connected component of } X \) in
  \[ \cap \{T \in D: T \supseteq X\} \]
main result: problem can be solved efficiently with a simple DFS algorithm for a general class of set systems (which for instance do not satisfy anti-monotonicity)

set system \((E, F)\) is **strongly accessible** if \(\emptyset \in F\) and for every \(X, Y \in F\) satisfying \(X \subseteq Y\), there exists an \(e \in Y \setminus X\) such that \(Y \setminus \{e\} \in F\).

\(\Rightarrow\) there is a sequence \(X = X_0, X_1, \ldots, X_k = Y\) s.t. \(|X_i \setminus X_{i-1}| = 1\) for \(i = 1, \ldots, k\)

formally the following statement holds:

**Thm:** For any finite strongly accessible set system \((E, F)\)

(i) given by a membership oracle \(M\) computable in time \(T_M\),

(ii) for any closure operator \(\rho: F \to F\), computable in time \(T_\rho\)

the family of closed sets can be listed with delay \(|E|^2 T_M T_\rho\).

Details at the poster!