Fraud Detection by Dense Subgraph Detection

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Fraud Detection

• Text-based methods

• Graph-based methods
  
  • Unexpected spectral patterns

  • Dense subgraphs
Dense Subgraph Detection

• Given a graph $G = (V, E)$ with vertices $V$ and edges $E \subseteq V \times V$.
• Find a subgraph $S$ such that $d(S)$ is maximized.
• Goldberg’s algorithm (1984)
  • Transferred to a min-cut problem which can be solved as a max-flow problem.
• Charikar’s algorithm (2000)
  • Approximation algorithm by greedy approach.
  • Provable 2-approximation guarantee.
Charikar’s algorithm on Undirected Graph

Figures from:
Charikar’s algorithm on Undirected Graph
Charikar’s algorithm on Undirected Graph

input: undirected graph $G = (V, E)$
output: $S$, a dense subgraph of $G$

1. set $G_n \leftarrow G$
2. for $k \leftarrow n$ downto 1
   2.1. let $v$ be the smallest degree vertex in $G_k$
   2.2. $G_{k-1} \leftarrow G_k \setminus \{v\}$
3. output the densest subgraph among $G_n, G_{n-1}, \ldots, G_1$
On Directed Graph

• Duplicate the vertices.
• Make $G$ into a bipartite graph.
Fraudar

**Require:** Bipartite $G = (\mathcal{U} \cup \mathcal{W}, \mathcal{E})$; density metric $g$ of the form in (1)

1: **procedure** FRAUDAR ($G, g$)
2: Construct priority tree $T$ from $\mathcal{U} \cup \mathcal{W}$
3: $\mathcal{X}_0 \gets \mathcal{U} \cup \mathcal{W}$
4: for $t = 1, \ldots, (m + n)$ do
5:     $i^* \leftarrow \text{arg max}_{i \in \mathcal{X}_t} g(\mathcal{X}_i \setminus \{i\})$
6:     Update priorities in $T$ for all neighbors of $i^*$
7:     $\mathcal{X}_t \leftarrow \mathcal{X}_{t-1} \setminus \{i^*\}$
8: end for
9: **return** $\text{arg max}_{\mathcal{X}_i \in \{\mathcal{X}_0, \ldots, \mathcal{X}_{m+n}\}} g(\mathcal{X}_i)$
10: **end procedure**

Runtime

- Utilized a priority tree
  - Fast minimum retrieval ($O(\log |V|)$)
  - Fast updating ($O(\log |V|)$)

- Total runtime: $O((|V| + |E|)\log |V|)$
Dataset

• Twitter data extracted in July 2009.
• 41.7 million users.
• 1.47 billion follows.
• Fraudar detected a 4031 followers by 4313 followees subgraph with density 68%.
• Human labeling: 57% of the detected followers are were labelled as fraudulent, deleted or suspended accounts.