VIS4AUI: VISUAL ANALYSIS OF BANKING ACTIVITY NETWORKS*

Walter Didimo, Giuseppe Liotta and Fabrizio Montecchiani
D.I.E.I., Universitá degli Studi di Perugia, Via Duranti 93, Perugia, Italy

Keywords: Information Visualization, Network Analysis, Graph Drawing, Clustering, Social Network Analysis, Multi-touch User Interfaces.

Abstract: We present the system VIS4AUI, aimed at supporting the analyst to discover financial crimes related to money laundering. An *anti-money laundering archive* collects financial information with regard to ongoing bank relationships and high value transactions. VIS4AUI is able to import and analyze the Italian anti-money laundering archive (AUI) in order to visualize the banking activity networks arising from it. In the demonstration, the user will be given an evidence of a possible suspicious person or company; starting from such a seed entity, the task will be that of exploring and analyzing her network of transactions through the tools provided by the system. In order to immerse the user in a fully interactive experience, VIS4AUI is a touch-optimized application, only requiring a touchscreen as interface.

1 INTRODUCTION

Money laundering is a well-known kind of financial crime based on relevant volumes of transactions to conceal the identity, the source, or the destination of illegally gained money. These transactions are conceived to give the illegally gained capitals a licit semblance, making their origin difficult to identify. To face this problem, most governments have created special investigation agencies, called *Financial Intelligence Units* (FIUs), whose main objectives are to defend the integrity of worldwide financial markets and to prevent them from organized crimes that could undermine the homeland security.

VIS4AUI is a system started from a proof of concept implementation described in (Didimo et al., 2011), and successively engineered by the academic spin-off Vis4[2], thanks to a close collaboration with the FIU of the Republic of San Marino (AIF - Agenzia di Informazione Finanziaria)[3]. VIS4AUI can import and analyze the anti-money laundering archive collected by Italian banks, named AUI (Archivio Unico Informatico). The AUI archive holds financial data with regard to ongoing bank relationships and transactions involving amounts exceeding EUR 15,000.00. These data can be modelled as social networks whose nodes represent persons and companies and whose links represent their relationships, see Figure 1. It is widely accepted that the exploration of such networks to discover criminal patterns strongly benefits from a strict integration of social network analysis (SNA) and visualization tools (Didimo and Liotta, 2007; Tang et al., 2010; Westphal, 2009; Xu and Chen, 2005).

2 THE SYSTEM VIS4AUI

In order to collect the system requirements we cooperated with analysts of the Republic of San Marino AIF. One important issue is that the system is not required to discover criminal patterns by itself, but it is mainly intended by the analyst as a strong support for the investigation activity. For this reason, the system must provide strong interaction, conceived for semi-automatic solutions.

The development of advanced methodologies and software systems for the analysis of criminal networks has received increasing attention after the September 11 terrorist attacks, see, e.g., (Chang et al., 2008; Tang et al., 2010; Klerks and Smeets, 2001; Goldberg and Senator, 1995; Chen et al., 2005; Stasko et al., 2008). A survey on these systems is presented by Xu and Chen (Xu and Chen, 2005).

*Thanks to the programming team of Vis4 for the great job done in the last year.

[2]http://www.vis4you.com/

[3]http://www.aif.sm

Didimo W., Liotta G. and Montecchiani F..
VIS4AUI: VISUAL ANALYSIS OF BANKING ACTIVITY NETWORKS.
DOI: 10.5220/0003933407990802
In *Proceedings of the International Conference on Computer Graphics Theory and Applications* (IVAPP-2012), pages 799-802
ISBN: 978-989-8565-02-0

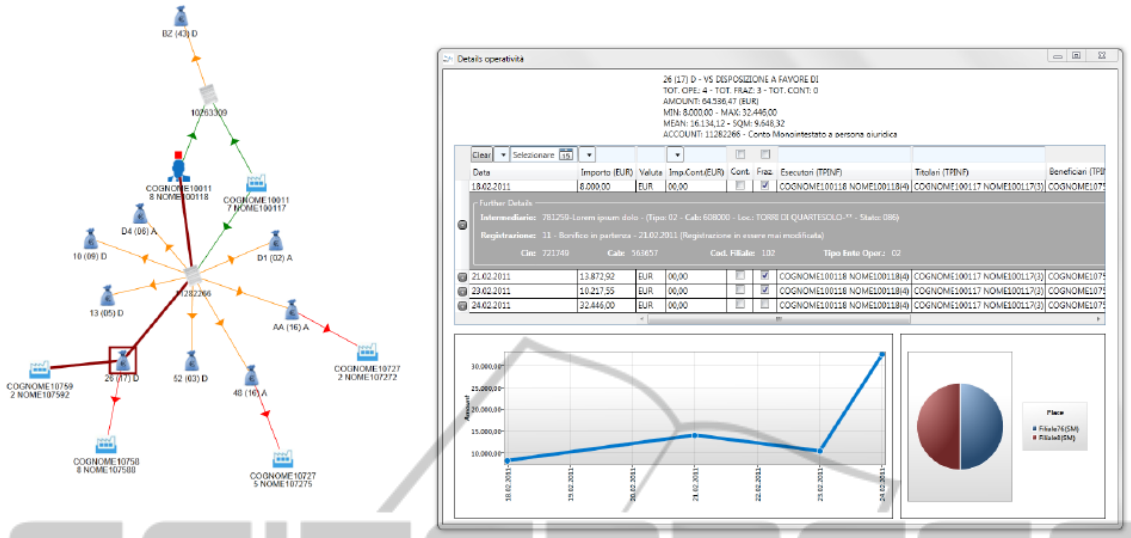

Figure 1: A bank activity network drawn by VIS4AUI. The near window shows some details about a subset of transactions involved in the network.

In the remainder of this section we summarize the main features of VIS4AUI; see (Didimo et al., 2011) for further details on the algorithmic aspects of the system.

2.1 Exploring and Analyzing the Network

The financial networks to be analyzed are automatically drawn by the system using a customized force-directed algorithm, which is able to handle position constraints and clusters. We recall that force-directed algorithms have been introduced by Eades (Eades, 1984) and received a lot of attention both in the graph visualization literature and in the implementation of industrial software, see, e.g., (Fruchterman and Reingold, 1991; Chen et al., 2005). The basic idea of a force-directed algorithm is to model the network as a physical system: Different kinds of forces are exerted on each node, and the final placement of all nodes in the visualization will correspond to an equilibrium status of the physical system.

In VIS4AUI, the visual exploration of the financial networks is supported by a combination of a *bottom-up* and of a *top-down* interaction paradigm. With the former one the analyst can start from a seminal node and iteratively enhance the network with new elements by adding neighbours of the displayed nodes. With the latter one the analyst can use hierarchical clustering to recursively aggregate elements on the whole network currently displayed. Each cluster can be collapsed or expanded independently at any time, so that the analyst can simplify the visual information at her convenience. These two kinds of interaction paradigms can be alternated while maintaining consistency.

Moreover, VIS4AUI makes it possible to mix automatic and manual clustering, and is equipped with several tools for social network analysis other than clustering, like different types of indices to measure the centrality of each actor in the network.

Finally, the intelligence process is also supported by a powerful saving system, which allows the user to revert to any previous save and to create a new branch of saves on the time-line (see Figure 2).

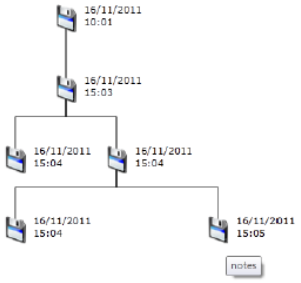

Figure 2: A tree of saves related to an investigation.

2.2 Interface and Interaction

Here we describe the interface and interaction of VIS4AUI in more details. The user interface of VIS4AUI is touch-optimized, hence every interaction described below can be performed using either a mouse or a touchscreen.

The analyst can start a new investigation from a desired *seed entity* (e.g., a person or a company),

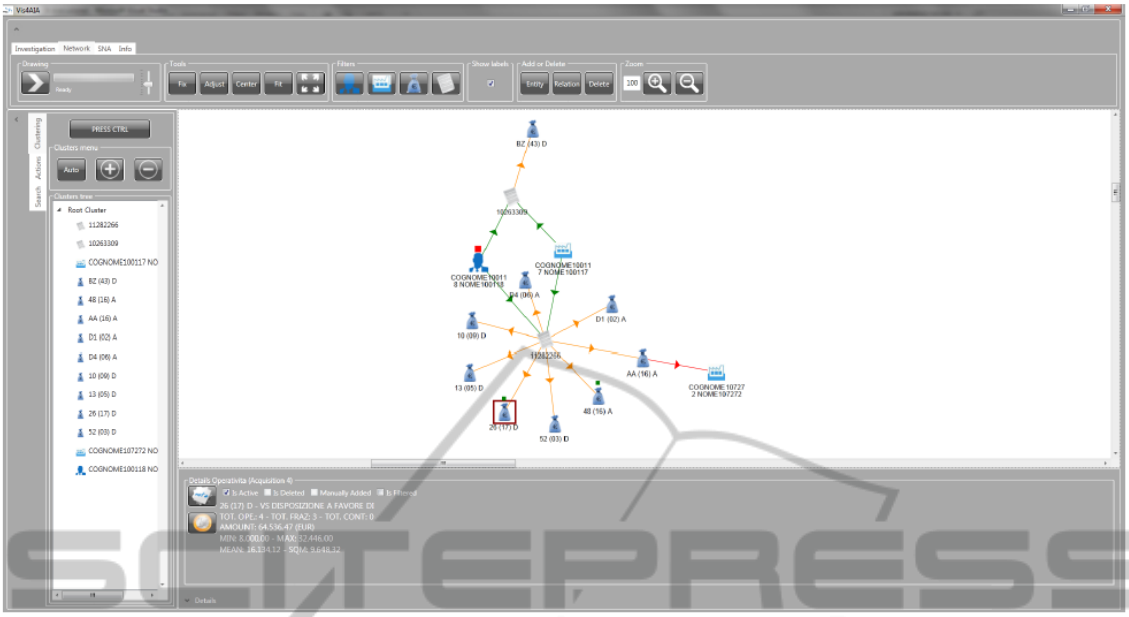

Figure 3: The main window of VIS4AUI.

searching in the database accessed by VIS4AUI. At the beginning only the seed entity and its adjacent nodes are displayed. The analyst can then explore and elaborate on the network with different interactive tools:

Bottom-up Exploration. The set of nodes and edges can be incrementally enhanced by exploring some of the displayed entities. By double clicking or double tapping a node, all of its neighbours and their connections are added to the current network, if not already shown. A new layout is automatically computed according to the status of the previous network, which depends on the presence of cluster regions or other types of geometric constraints. If the previous drawing contained a hierarchy of cluster regions, every node that enters in the new network is automatically assigned to a suitable cluster region according to a criterion aimed at keeping the coherence of the clustering. A small green box over a node indicates that such a node has not been explored yet; this avoids the analyst to repeat the same exploration action twice.

Top-down Exploration. The analyst can ask the system to automatically compute a cluster hierarchy on the current network. This action will group nodes into clusters and sub-clusters according to some specific algorithm. Our current clustering algorithm exploits the concept of *k-core*, which has been proven to be effective for discovering relevant groups in social networks, see, e.g., (Batagelj et al., 1999; Dorogovtsev et al., 2005; Goltsev et al., 2006; Seidman, 1983). However, different types of clustering algorithms can be easily plugged in the system. Once a cluster hierarchy has been computed, the system decides the initial dimensions of each cluster region based on the number of nodes inside it. In the layout, the boundary of each cluster region is displayed as a rectangle. To help the analyst in capturing the structure of the cluster hierarchy, the corresponding cluster inclusion tree is also displayed on the left-hand side of the interface. VIS4AUI offers various interaction facilities with the clusters and their regions. The analyst can drag nodes inside or outside a cluster region, so modifying its associated cluster. She can move a cluster inside or outside another cluster, so modifying the cluster hierarchy. She can create new clusters or delete some of the existing ones. She can collapse or expand a cluster region, so to hide/show its interior. The drawing algorithm will react at each user's change in order to rearrange the layout. The analyst can also resize each cluster region at her convenience with the same kind of interaction used to resize a window in a classical operating system graphical user interface, that is, dragging the boundary of the cluster. Resizing clusters acts as a focus+context technique with multiple foci.

Node Centrality. VIS4AUI implements a wide range of indices for measuring the centrality of a node, like betweenness, closeness and degree. The value of a specific type of index is conveyed in the layout by displaying a small disk near to its associated node, the color of the disk reflect the value in a scale from white to black. The analysts can quickly switch from the visualization of a type of index to another and all indices are normalized so that they can be eas-

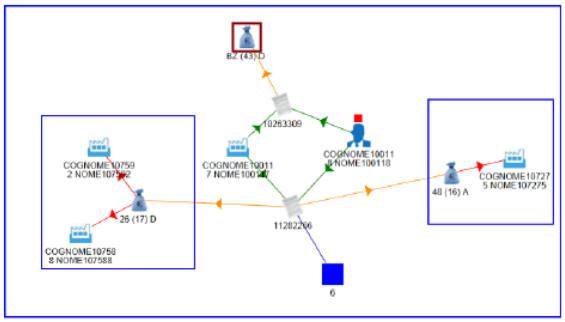

Figure 4: A clustered network with one collapsed cluster.

ily compared. We remark that centrality indices make sense only for nodes representing the actors of the network, like persons, companies, and banks. Hence, in order to compute the centrality of these actors, we run the algorithm on a different suitable network consisting only of actors. Namely, we add an edge between two actors if the length of the shortest path between them is at most d (for a pre-set constant d), and then we remove all nodes that are not actors.

3 DEMO PROPOSAL

The database of the system will be loaded with an anonymized anti-money laundering archive. In the demonstration, the user will be given an evidence of a possible suspicious person or company. An evidence can be for example a set of suspicious transactions made by a person or by a company. Starting from this seed entity, the task will be that of exploring and analyzing the related network using the tools provided in the system. User's impressions and comments will be recorded by means of an interview.

Figure 5: A user interacting with VIS4AUI by a touchscreen.

REFERENCES

Batagelj, V., Mrvar, A., and Zaveršnik, M. (1999). Partitioning approach to visualization of large networks. In *GD 1999*, volume 1731 of *LNCS*, pages 90–97.

Chang et al., R. (2008). Scalable and interactive visual analysis of financal wire transactions for fraud detection. *Information Visualization*, 7(1):63–76.

Chen, H., Atabakhsh, H., Tseng, C., Marshall, B., Kaza, S., Eggers, S., Gowda, H., Shah, A., Petersen, T., and Violette, C. (2005). Visualization in law enforcement. In *CHI*, pages 1268–1271. ACM.

Didimo, W. and Liotta, G. (2007). *Mining Graph Data*, chapter Graph Visualization and Data Mining, pages 35–64. Wiley.

Didimo, W., Liotta, G., Montecchiani, F., and Palladino, P. (2011). An advanced network visualization system for financial crime detection. In *PacificVis*, pages 203–210. IEEE.

Dorogovtsev, S. N., Goltsev, A. V., and Mendes, J. F. F. (2005). k-core organization of complex networks. *CoRR*, abs/cond-mat/0509102.

Eades, P. (1984). A heuristic for graph drawing. In *Congressus Numerantium*, volume 42, pages 149–160.

Fruchterman, T. M. J. and Reingold, E. M. (1991). Graph drawing by force-directed placement. *Softw., Pract. Exper.*, 21(11):1129–1164.

Goldberg, H. G. and Senator, T. E. (1995). Restructuring databases for knowledge discovery by consolidation and link formation. In *Proceedings of the First International Conference on Knowledge Discovery and Data Mining*, pages 136–141. AAAI Press.

Goltsev, A. V., Dorogovtsev, S. N., and Mendes, J. F. F. (2006). k-core (bootstrap) percolation on complex networks: Critical phenomena and nonlocal effects. *CoRR*, abs/cond-mat/0602611.

Klerks, P. and Smeets, E. (2001). The network paradigm applied to criminal organizations: Theoretical nitpicking or a relevant doctrine for investigators? Recent developments in the netherlands. *Connections*, 24:53–65.

Seidman, S. B. (1983). Network structure and minimum degree. *Social Networks*, 5:269–287.

Stasko, J., Görg, C., and Liu, Z. (2008). Jigsaw: supporting investigative analysis through interactive visualization. *Information Visualization*, 7:118–132.

Tang, L., Barbier, G., Liu, H., and Zhang, J. (2010). A social network analysis approach to detecting suspicious online financial activities. In *Advances in Social Computing*, LNCS, pages 390–397.

Westphal, C. (2009). *Data Mining for Intelligence, Fraud, & Criminal Detection*. CRC Press.

Xu, J. and Chen, H. (2005). Criminal network analysis and visualization. *Comm. of the ACM*, 48(6):101–107.