

# Analyse Visuelle pour l'Analyse de Réseaux Sociaux Historiques

## *Visual Analytics for Historical Network Research*

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# 1 - Introduction

Social scientists such as historians and sociologists want to make sense of the structure and evolutions of the social relationships between people of a given place and time. Social Network Analysis (SNA), also called Historical Social Network Analysis (HSNA) when applied on historical data, is one of the main method—sometimes referred as a paradigm—to achieve this goal, and grew in popularity in recent years as the concept of network became a widespread abstract in many empirical sciences. It consists in modeling the social relationships between agents—such as persons or organizations—as a network and studying its local and global structure to make sociological conclusions. Compared to other more classical sociological approaches, “it is based on an assumption of the importance of relationships among interacting units. The social network perspective encompasses theories, models, and applications that are expressed in terms of relational concepts or processes.” [?]. Social historians rely on textual documents—such as marriage acts, birth certificate, and migration acts—and try to exhaustively extract all mentions of social relationships between persons that they model into a social network, where the nodes usually model persons, and links social relationships. Using mathematical computations and measures to characterize the network’s structure, they are able to make sociological conclusions on relational sociological phenomena based on real observations.

They also rely on Social Network Visualization (SNV) to make useful representations of social networks, and use visual analytics tools that allow them an effective exploration and analysis of this type of data, based on direct interaction and manipulation to find relevant structures. However, the process leading to the analyzable network from the historical documents is quite complex and not well documented. Specifically, historians can model their networks in many ways, and choosing a model loosely can lead to simplifications and distortions in the social reality and the final analyses. Most VA tools currently focus on the analysis part only of the process and do not help social historians in their annotation, cleaning and modeling steps. Similarly, automatic algorithms capabilities such as clustering are often available to help making sense of the network structure, but making sense of the results from a sociological lens is complicated especially without guidance, and social scientist have become frustrated by the use of these softwares. This thesis’s goal is to 1) shed light on the workflow of historians following a network analysis, to provide research directions towards new VA interface to help social scientists in their overall work, 2) provide VA interfaces which focus on complex interactions to help social scientists answer their complex questions while 3) focusing on the usability of those systems, especially concerning the traceability and interpretations of the results.

**def histoire**

## 1.1 . Social History and Historical Social Network Analysis

SNA is now a widely used method among historians to study relational phenomena like kinship, business, and institutions of the past, using network concepts and methods. It appeared to them as an effective way to study their sources after a long process of History methodology changes and discussions [9]. We can trace it back to the birth of Social History with the “Annale School” in the 1930s, where Historians gained interest in socio-economic questions, and started to rely heavily on the exhaustive extraction and analysis of historical documents coming from archives [?]. Beforehand, History was mainly political and event-centered, as the majority of works consisted in finding and expliciting specific events—such as wars or diplomatic alliances—while eliciting their causes and consequences, and narrating the lives of historic figures, such as sovereigns and artists. Social History shifted the focus by trying to link together sociological, economical and political issues and by placing individuals in the center of these questions [60].

Later on in the 1960s, with the development of Computer Science, historians started to use quantitative methods to analyze data extracted from historical documents and make conclusions grounded in statistical results, in various subjects like demographics [] or economics [].

Around the same time, the use and study of networks started to become popular in various disciplines to study real world relational phenomena based on mathematical computations and measures. A network is an abstraction based on graph theory concepts used to model relational phenomena based on relationships (called links) between entities (called nodes).

Sociologists started to use this concept to model social ties between agents of interest—very often persons—and study social phenomena through the description of the network structure, using the SNA methodology. It allowed them to leverage quantitative measures from the network to make sociological conclusions based on real observations, instead on relying on traditional social categories such as the age, job, and gender. It has been applied to study various subjects like families, political institutions, schools, friendships, work environments, and sports clubs, with promising results. This method grew in popularity in recent years, and has started to be used and formalized by historians in the 1980s, under the term of Historical Network Research (HNR) or Historical Social Network Analysis (HSNA) [72]. It allowed historians to study relational phenomena of the past—such as families and institution—through real social relationships directly extracted from historical documents and modeled into a network. These documents can be anything mentioning social relationships between actors of interests, such as marriage acts, birth certificates, census, migration acts and working contracts. After selecting a corpus of documents (often extracted from archives), they manually annotate each document to extract the mentions of persons along their relationships to model those with a network. This is a long and tedious process which can result in small to large networks that they analyze using mathematical measures to make conclusions on

historical phenomena. **Talk about the HSNA process overall probably here** Historians usually rely on Social Network Visualization (SNV) to represent visually their data. It allows them to test their hypotheses visually, and communicate their findings.

## 1.2 . Visualization and Visual Analytics

Visualization is the process of displaying data visually to leverage the human visual system and enhance cognition and insight on the data. As data keeps growing in size with time, visualization is a powerful tool to gain insight on the underlying structure of various datasets. Visualization is mainly used for confirmatory and communication purposed, particularly in social sciences. Analysts generally have hypotheses that they want to test : they collect data, model it, compute measures, and plot the data visually to verify that it matches the results. They usually use similar plots to communicate findings, for example in scientific reports and presentations. Social scientists following a network analysis typically plot their data using node-link diagrams, which allow them to represent a network with circles and lines to respectively represent nodes and links. It let them confirm or deny some of their hypotheses by observing the network structure, and communicate on their results.

However, visualization can also be used for exploration, which can help understanding the underlying structure of data and generate new hypotheses. Tukey defined this process as Exploratory Data Analysis (EDA) in the 1960s [?], as a procedure to gain insight on the structure of the data by identifying outliers, trends and, patterns with the usage of visualization and statistical measures. Interaction in visualization help this process by letting users navigating more easily on multi-variate datasets with the help of direct manipulation on the data. The detection of patterns and trends can also be facilitated with automatic methods coming from data mining and machine learning fields, directly implemented in the visual analysis loop. This coupling of visual exploration and automatic data mining algorithms have been coined as Visual Analytics, and is defined as the process of using interactive visualizations, transformations, models of the data in a analysis workflow to create knowledge.

EDA and VA are currently not widely used in HSNA, as social historians always have prior hypotheses before getting their data in shape. However, datasets that historians produce are getting bigger and bigger and VA tools are efficient tools to explore such datasets and generate insights and new hypotheses.

## 1.3 . Historical Social Networks Visual Analytics

Currently, social historians spend a lot of time in their data acquisition, processing and cleaning steps which lead them to the construction of a network. They typically visualize and analyze their network at the very end of this process only.

This can be explained in part because most VA tools focus only on this final analysis and not on the preprocessing steps. Social historians collect, annotate and clean their data using custom scripts and ad-hoc methods before doing any analysis. However, research showed that all the steps preceding the analysis can introduce errors and misconceptions, especially that social scientists are often not trained in Computer Science and Data Science [2]. Social scientists visualize their network using SNA tools like Gephi, Pajek, and NodeXL which englobe node-link visualization, SNA measure computations and clustering algorithms. Once they visualize their data, they typically notice errors and inconsistencies in the data. They therefore have to do back and forth between the visualization software and the cleaning process which can be tedious. VA tools which englobe the whole process of social historians should therefore be beneficial for the flow of their work and could help detect and correct errors or analysis plans way before the final analysis.

Moreover, social scientists have been frustrated by current data mining tools as the results they get from tasks such as clustering and classification come from black-box algorithms, may mismatch their vision of the data, and they may feel they do not have control over the analysis. One of the reason is that automatic results can be hard to interpret, especially in a discipline such as History or Sociology, where users often have little knowledge on computer science.

#### **1.4 . Contribution and research statement**

As seen in section 1.3, most VA tools for HSNA are focused on the final analysis. We think VA could help social historians in their entire workflow, from data acquisition to analysis, instead of focusing only on the final steps. Concerning the analysis, VA tools should satisfy constraints of social historians, i.e. being able to answer complex questions with effective visual representations, letting the user in control of the analysis loop and algorithmic results, and satisfying traceability to the original sources. The goal of this thesis is to give answers to the high-level question “How can VA help social historians in their entire HSNA process?”. To answer this question, we first characterize the HSNA process from start to finish, with the goal of identifying pitfalls and problems that regularly arise and characterizing social historians needs. From this, we give answers to three issues that frequently arise in social scientists workflows :

- Q1** : How should historians model their documents into an analyzable network which satisfy their constraints ?
- Q2** : What representations and interactions are necessary for social historians to answer complex historical questions while being easy enough to navigate ?
- Q3** : How to design VA tools and interactions that let historians in control of the analysis loop, without introducing bias ?



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