SocioScape – a Tool for Interactive Exploration of Spatio-Temporal Group Dynamics in Social Networks

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Abstract

We introduce SocioScape, an interactive tool for the visual exploration of spatially referenced, dynamic social networks. The tool combines a novel depiction methodology that illustrates the evolution of social groups with a spatio-temporal visualization showing the movement of these groups in the environment. The depiction technique used by SocioScape provides an alternative to graphs, allowing domain scientists to easily explore the evolution of the social structure and examine the role of the environment in shaping the social behavior of populations.

Keywords: information visualization, social networks, data exploration

Index Terms: H.5.2 [Information Interfaces & Presentation]: User Interfaces – Graphical User Interfaces (GUI).

1 Introduction

Social networks are abstract representations of social relationships or interaction between individuals for the purpose of studying processes that occur on a societal level. The field of social network analysis has witnessed an unprecedented growth in the past few years. Scientists from increasingly diverse disciplines, including ecology and epidemiology are using social networks to model a wide variety of phenomena. This growth has also been characterized by an increasing shift toward dynamic models in which the relationships between individuals change over time [1].

One of the goals of social network analysts is revealing the social groups in the network, and how these groups evolve over time. Social groups are characterized by densely-knit groups of individuals interacting closely with each other. Traditional social network visualization techniques have predominantly embraced graph drawing as the main method to visually represent social networks. Individuals are depicted with nodes, while an edge depicts interaction or a relationship between a pair of individuals. Graph drawing is generally recognized as an effective method for visualizing static social networks in which the graph does not change over time. However, this method become problematic with dynamic networks in which the graph evolves to depict the changing social structure [2]. The most commonly used technique to visualize dynamic graphs uses animation to depict the passage of time [5]. This method allows the viewer to observe momentarily structural changes that occur over few frames, but makes it difficult to perceive the overall pattern of interaction. Another technique is "unrolling" the graph in the temporal dimension by drawing several snapshots of the graph at different timesteps, and arranging them on top of each other [6]. However, this technique is limited to visualizing a few timesteps at a time, as simply stacking up more snapshots will produce a cluttered visualization.

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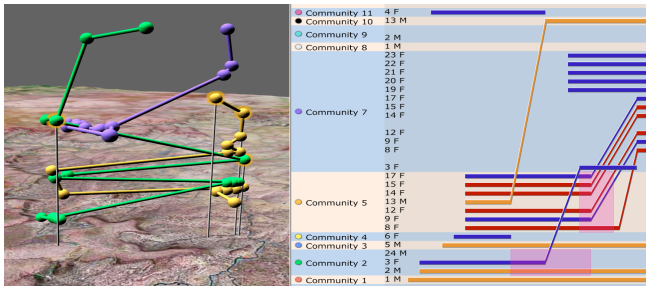

Figure 1. SocioScape visualizing the movement of Grevy's zebra groups (left) and the social composition of these groups (right)

2 Problems with real-world social networks

Scientists working with real-world social networks are increasingly faced with dynamic datasets embodying complex social relationships. Using current tools, scientists find it difficult to effectively explore the evolution of the social structure and come up with hypotheses on the role of various environmental factors in shaping that structure. For example, ecologists from the Equid Research and Conservation center located at the University of Princeton collect data about the social interaction of zebras and wild horses by observing these animals in the wild over periods spanning several months. The collected data comprises sightings of individual zebras along with their GPS position. Individuals that were observed in spatial proximity to each other are considered to be interacting with each other at the time of sighting.

Using current visualization tools, ecologists can look at graphs depicting interactions between pairs of animals. The passage of time is simulated using animation, or the graph is unrolled in time. Both of these techniques are not effective at exploring social groups and their evolution at temporally fine-grained scales. Furthermore, ecologists are also interested in how the atomic decision making of individuals embodied by their physical movement shapes the structure of zebra society. However, the vast majority of tools visualize the social structure abstractly, and present it out of context of the physical environment in which the interaction takes place. This makes it difficult for scientists to explore the role of the environment in influencing the social behavior.

SocioScape is an interactive visualization tool that explicitly illustrates the social groups present in the network and follows their evolution over time. It also features a spatio-temporal visualization allowing scientists to explore how the movement of groups and individuals in the environment affects the social structure of the population.

3 Overview of SocioScape

SocioScape focuses on revealing the social groups present in the population, and how these groups evolve over time. To achieve this, we start with a dynamic social network represented by a series of static graphs depicting individuals that were observed interacting with each other at different timesteps. A dynamic group identification algorithm proposed in [3] is used to infer the social groups in the network and establish a stable labeling for instances of these groups across all the static snapshots. The dynamic groups are referred to as "communities". A community is a grouping of individuals that persists over time, while allowing new members to join and existing members to leave. However, an individual can only be affiliated with one community at a particular timestep.

SocioScape supports two depiction techniques: the Affiliation Timeline, which depicts the community structure of the population and its evolution over time, and the space-time cube, which shows the movement of communities in the physical environment.

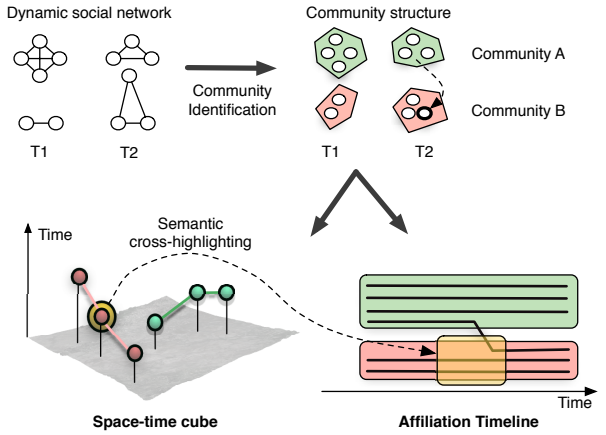

Figure 2. SocioScape's pipeline and depiction technique

3.1 Affiliation Timeline

One of the problems of using graphs to analyze dynamic social networks is that it is difficult to see densely-knit groups of individuals who interact closely with each other, and observe how these groups evolve over time. To address this, SocioScape introduces the Affiliation Timeline, a 2D layout similar to a parallel coordinate diagram used to explicitly illustrate the evolution of communities over time. The X axis represents time, while communities and individuals are arranged on the Y axis. Communities are depicted with non-overlapping rectangles where each rectangle represents one community, with the different communities arranged on top of each other. Individuals are depicted with lines that fall within the community with which they are affiliated. At a particular moment in time, all individuals falling within the same rectangle (i.e., the same community) are said to be affiliated with that community. The diagram groups individuals based on their shared community affiliation, rather than drawing edges between them to indicate mutual interaction. This produces a stable layout and eliminates the clutter that results from edge-crossing in graphs. Each individual has exactly one contiguous line. A straight horizontal line indicates that the individual remains affiliated with its community. When the individual leaves its community and joins another one, its line is skewed towards the new community at the timestep the switch had occurred. This layout clearly depicts interesting events in the network such as one or more individual leaving the community at the same timestep.

3.2 Space-time cube

The space-time cube is a 3D visualization that is based on the work of Kraak [4]. It depicts the movement of communities in the physical environment over time. The base of the cube depicts the spatial dimension, while the vertical axis is used to depict time. The cube's base is a 3D topological map of the region in which the social interaction takes place. Communities are depicted using spheres. Their horizontal placement reflects the physical position of the community in the environment at the time of sighting, whereas their vertical position reflects the time of sighting. A line connects two consecutive sightings to depict the movement of the community. A vertical line is projected from the spheres onto the topological map to disambiguate the physical position of the sighting location.

The two visualizations can be used to display the same social network side-by-side, allowing an analyst to see both the community structure, as well as the geographical position and movement of the communities over time. To amplify the analyst's ability to correlate the spatial and temporal aspects of the social interaction, SocioScape provides a semantic cross-highlighting feature. Data selected in one of the diagrams causes related data to be automatically highlighted in the other. For example, the user can select one of the community sighting locations in the space-time cube visualization by simply clicking the sphere. This in turn causes a portion of that community's rectangle to be automatically highlighted in the Affiliation Timeline. The highlighted portion shows the individuals affiliated with that community at the time of sighting.

4 Conclusion

Graph drawing has been the predominant method for generating visual representations of social networks. However, graphs have shown to be limited when applied to dynamic networks that change with time. SocioScape is a novel visualization tool for the exploration of group dynamics in spatially referenced, dynamic social networks providing an alternative to graphs.

We conducted a user study in which the tool was used by a group of expert ecologists researching the social behavior of Grevy's zebra. The reviews were very positive. SocioScape provided a more intuitive alternative to graphs when exploring the evolution of social groups. Furthermore, the integration of the spatio-temporal visualization enabled ecologists to explore the role of geography in shaping the underlying social structure of wild animals, and how that structure evolves over time.

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