

Visualizing and Analyzing Identity Classes in Evolving Social Structures

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Social networks are usually represented as graphs with each person as a node and each social relationship as an edge. As frequently observed, if one considers social structures over time, those relationships, indeed even the people, come and go so that a static graph does not capture important aspects of the overall situation. Adding a temporal component to the graph results in specifying an evolving network [1, 3, 6, 7, 9–12, 20]. In formulating evolving networks for several motivating applications, we have found the need to extend those specifications. In particular, we consider an entity (or relationship) that evolves, that is, has characteristics that change over time: fundamental characteristics that determine the entity’s identity. Our prime motivating application for our extensions is the marital structures of the mid-1800s Mormon church in Nauvoo, Illinois. However, we note that there are other applications for which we see the need for these extensions, including co-citation graphs and corporate communication networks.

Represented in the Nauvoo dataset is a rich collection of marital and family structures, including polygynous and polyandrous marriages. The historical development of these social structures is the focus of our humanities research (as discussed in [15]). We represent the marriages as the nodes, with the edges between nodes representing the individuals participating in marriages; that is, an edge representing an individual will connect the marriage of their biological parents with their own adult marriage. Each of these marital structures, as well as the network as a whole, are considered to be evolving as marriages form and partners, children, and adoptees are brought in and leave.

One form of the evolving network described above can be derived by stipulating that each node represents the marriage of exactly one woman and one man, i.e., the nodes are considered to be binary marriages, together with their offspring. However, for our research it is important to move beyond the conceptualization of binary marriages to focus on the richer familial interactions presented. To enable consideration of important aspects of this research, we introduce the concept of an “identity function” that takes an evolving network and creates a new evolving network by applying criteria to determine what constitutes a node, i.e., determines the node identity. For example, if instead of each node being identified by the exact woman/man pair, we extended the identity to be based on the man, and include all the women married to him, a new evolving network of polygamous marital structures emerges. The identity function that transforms the binary-marriage network into this new network we call, $V_{patriarchal}$.

A similar identity function can be designed in which the identity of each node is based on a specific woman and includes the men married to her. We call that identity function, $V_{matriarchal}$. Given the similarity of the criteria for these two identity functions, one might imagine that the two resulting evolving networks would stand in relation to one another much as a static graph and its dual [2]; however, that is not the case. We believe aspects of the differences in the network

characteristics, particularly the dynamics within each evolving network, are indicative of important facets of the early Mormon social structures as they developed.

On the computer science side, we have two foci: visualization methods and quantifiable measures over our extended evolving networks. First, to visualize the familial structures, we form evolving lineage diagrams [16] that are similar to flow diagrams [13, p. 153–158], with a “generational” flow. As stated above, each node represents a marriage (under a particular identity function) and is visualized by a modified chord diagram [14, 17–19, 22] to provide a 2D representation of the marriage at one specific point in time. This representation may then be visually layered to depict the evolution of the specific marriage, such as a new person joining the marriage. Our extension and corresponding visualization techniques have enabled fresh views of individual marriages and the larger lineage structures, with those views being evocative, even provocative, to historians: specifically, the potential of the techniques to enable analysis of women’s liberty to marry and divorce, largely at will. Though this liberty has long been known by scholars, discussion of it has been limited to anecdotal accounts; there has been no attempt to measure it on a social scale.

Secondly, we intend to provide means for our evolving network representations to become an analytical basis for conclusions by historians. To that end, we adapt quantitative measures of network characteristics, e.g., global temporal centrality and connectedness [4, 5, 8, 21], to the extensions we have made, particularly those networks under alternative “identity functions.” We believe these measures will allow scholars to quantitatively characterize and compare the dynamics of the lineages of various individuals in the developmental years in Nauvoo.

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