

# Spatio-Temporal Genealogy Visualization with WorldLines

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## **Abstract**

The focus of conventional genealogy visualization techniques lies on showing generational and perhaps temporal relationships. A family tree, for instance, perfectly shows dates of birth and death of a person, who is the child of whom, as well as marriages and divorces. But to fully understand an individual's life, it is important to know some more facts: Where was the person born? When did she or he leave home? How often and where to did that person move? Where did people meet?

We propose a combination of a space-time cube and a timeline visualization to be able to actually see a person's life. The timeline visualization shows generational and temporal relationships, where the space-time cube visualizes spatial relationships and movements of a single person as well as those of whole families. Event clouds (additional information layers for historic events) can further show possible connections between such events and migration of a person/family.

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# Introduction

## 1.1 Motivation

“Who am I?”

Answers to the general question “Who are you?” will vary most often a great deal. It depends upon the person and the context in which the question is being asked.

One might answer with her or his name at first, and, if the context allows, where and/or when one was born. We could continue with our occupation and our hobbies, describing ourself more and more in detail.

If we ask *ourself* this very same question, we might think about our individual achievements or social and economic status. We might also reflect our cultural and/or religious background. Finally, we might also look back at our own ancestors, to find out who we are.

This is exactly what the Māori are doing. They learn *whakapapa*, the “genealogical descent of all living things from the gods to the present time” [Barlow, 1994, p. 173], to discover who they are.

Even by looking at our own name, we are automatically looking back at our ancestors. For example, in Portugal the law allows a person to have up to two first names and up to four family names [Instituto dos Registos e Notariado, 2013]. Generally, the child will receive both its mother’s *and* its father’s surname(s). If the mother and father themselves have gotten both their parents’ surnames, then the child successively could have family names from all of its four grandparents.

So, asking oneself the *simple* question of “Who am I?” might easily become a starting point into genealogy.

## 1.2 Problem

During the Middle Ages, genealogy was practiced almost exclusively by rulers and nobles as a way to demonstrate the legitimacy of claims to wealth and power. An *ahnentafel* (german for

Table 1.1: An *ahnentafel* over four generations.

I	II	III	IV
1 subject	2 father	4 paternal grandfather	8 great-grandfather
			9 great-grandmother
		5 paternal grandmother	10 great-grandfather
			11 great-grandmother
	3 mother	6 maternal grandfather	12 great-grandfather
			13 great-grandmother
		7 maternal grandmother	14 great-grandfather
			15 great-grandmother

“ancestor table”), as seen in Table 1.1, perfectly shows all the ancestors of a person, and was therefore enough.

Nowadays, people do genealogical research for different reasons [Mills, 2003]. They want to learn who they are by learning their family history and where their family came from. They want to know what people’s lives actually looked like. But a person’s life might not be exclusively influenced by generational relationships, so we might want to see all relevant temporal relationships as well. Figure 1.1 shows a modified descendant chart, that tries to accomplish that by showing labels for marriages and divorces.

But still, this visualization does have flaws. For example, places are not visualized at all. It does not show if/when a person left home (for college, university, etc.), or where a person went and how many times that person moved. We can not see where a person, marrying into a family, is coming from nor where two people have met.

Another problem with currently existing genealogy visualisations is that they do not show temporal attributes [Kim et al., 2010], and if though, only by textual labels (see the labels for marriages and divorces in Fig. 1.1). Duration of a marriage is not visualized nor how soon a person got married again after a divorce. And if we want to find all people alive at a specific time we would have to process all the dates of birth and death for every single person.

### 1.3 Contribution

We propose to visualize a person with her/his space-time path in a Space-Time Cube (see section 2.2). That way, probable migration patterns and possible connections between world events (wars, diseases, etc.) and personal events (birth, death, marriage, migration) could be found. Additionally to the Space-Time Cube visualization we use a timeline visualization that shows not only parent-child relationships but also temporal relationships.



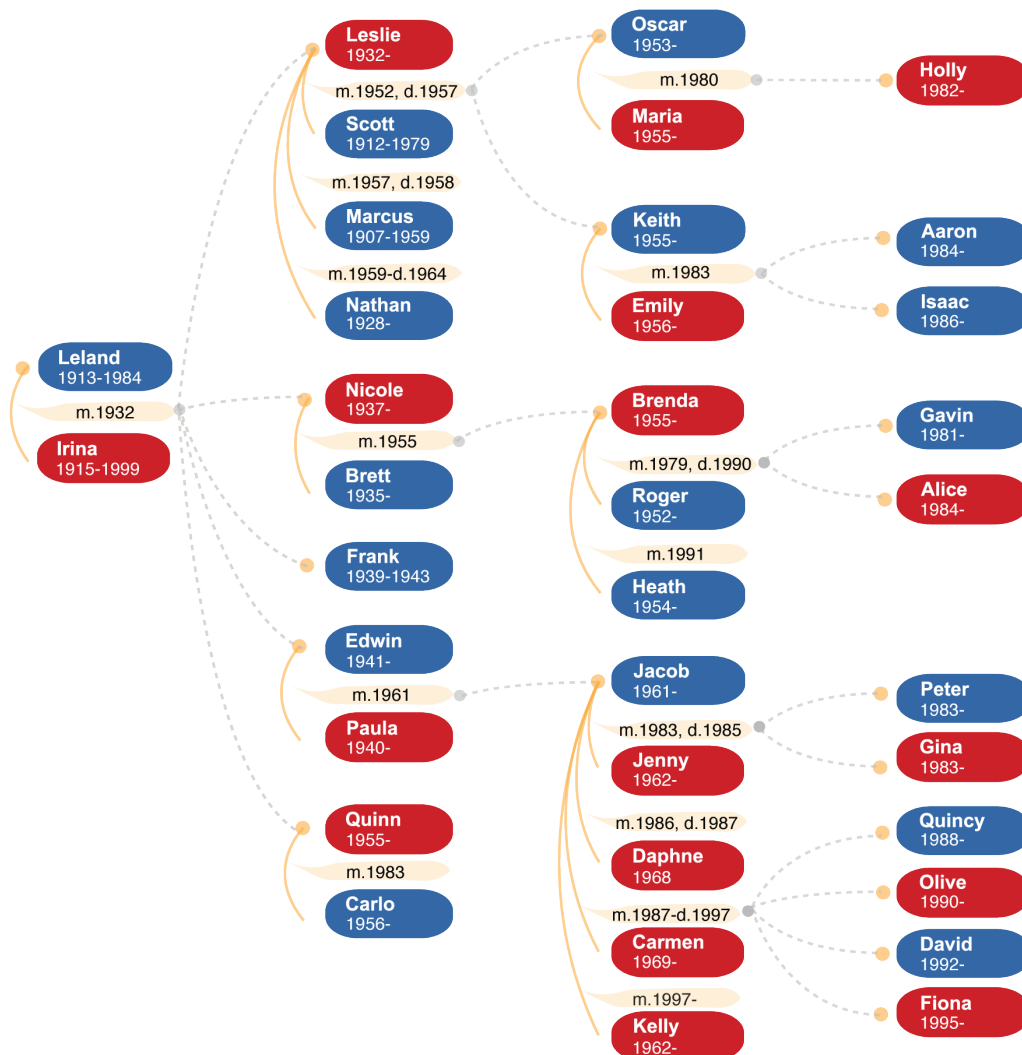


Figure 1.1: Family tree that shows all the descendants of Leland and Irina [Kim et al., 2010]. Generational relationships are indicated by dashed lines. Temporal relationships (solid lines) are labeled with their beginning and optional end dates.



## Related Work

### 2.1 Genealogy Visualization

Otto Forst described in *Handbuch der Praktischen Genealogie* [Heydenreich et al., 1913, page 42] the “two types of thinking in genealogy” (original: “die beiden Grundtypen genealogischen Denkens”). He basically differentiated between the *Deszendenztafel* (german for “descendant table”) and the *Aszendenztafel/Ahnentafel* (german for “ancestor table”). Table 1.1 is an example for such an ahnentafel. We already discussed the problems with these kinds of visualizations in section 1.2.

An inspiration for the way our tool visualizes temporal as well as parent-child relationships was TimeNets. With TimeNets, a visualization technique by Kim et al. [2010], people’s lives are displayed as timelines. The advantage of this technique lies in its ability to visualize complex relationships (remarriage, plural marriage, etc.) by “laying them out on individual lifespan timelines” [Kim et al., 2010]. Figure 2.1 shows a TimeNets visualization of the same family already seen in Figure 1.1. Now, we can easily find all people alive at a specific time.

### 2.2 Spatio-Temporal Visualization

Spatio-temporal data (events) can be visualized in two different ways: using either two or three dimensions. If we use a two dimensional static map all events are displayed. As events can have different occurrences in time, labels are needed which show their occurrence. On two dimensional *interactive* visualizations, where only events are displayed corresponding to the selected time (or time interval), labels for events are not needed.

Visualizing spatio-temporal data in three dimensions is actually using a technique called the Space-Time Cube (STC). The STC is a cube with a geographical map as its ground plane and time as its z-axis. Torsten Hägerstrand developed the idea for the STC during his research on human migration patterns in the mid 1960s [Lenntrop, 1999]. “In time-space the individual describes a path, starting at the point of birth and ending at the point of death.” [Hägerstrand, 1970]

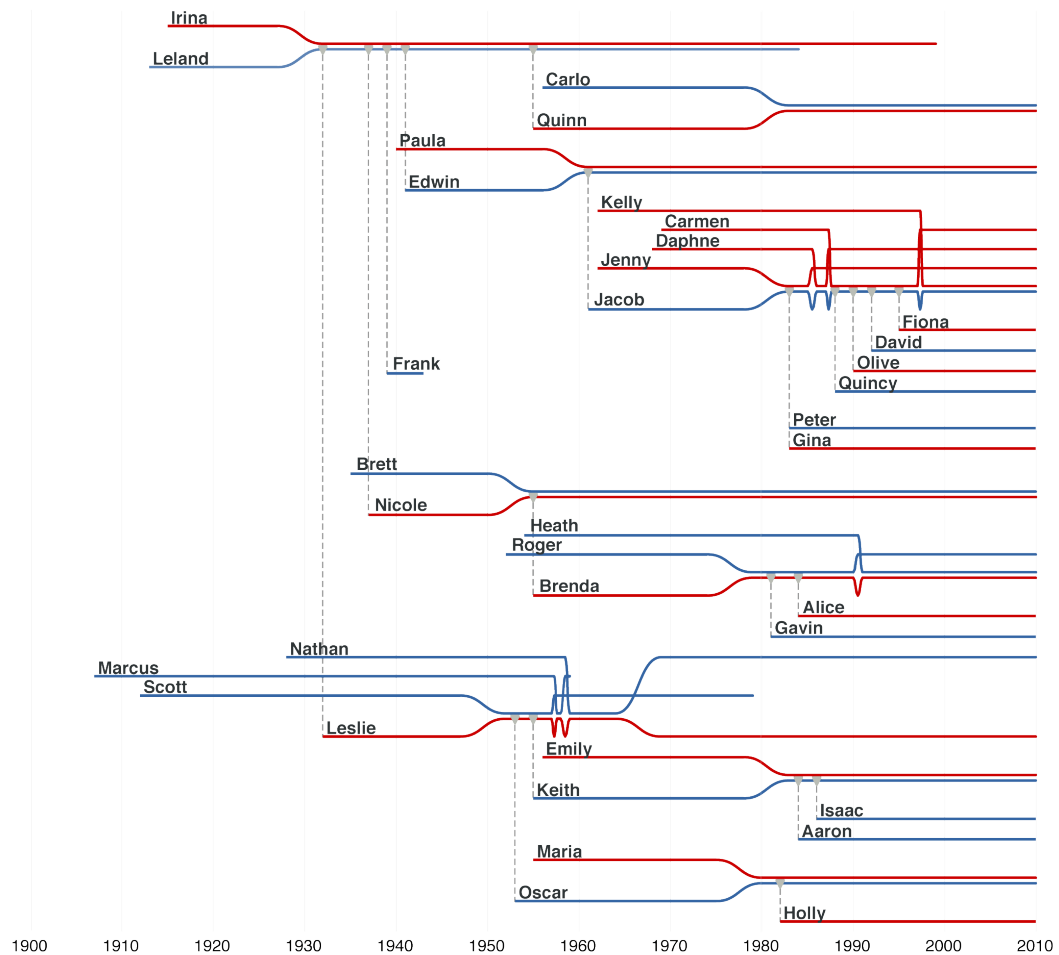


Figure 2.1: TimeNet visualization of the same family seen in Figure 1.1. Lifelines represent people, converging lines signify marriage, and drop lines indicate children. Image source: Kim et al. [2010]

Figure 2.2 shows the visualization of Charles Joseph Minard's *Napoleon's Russian campaign in 1812* using the Space-Time Cube.

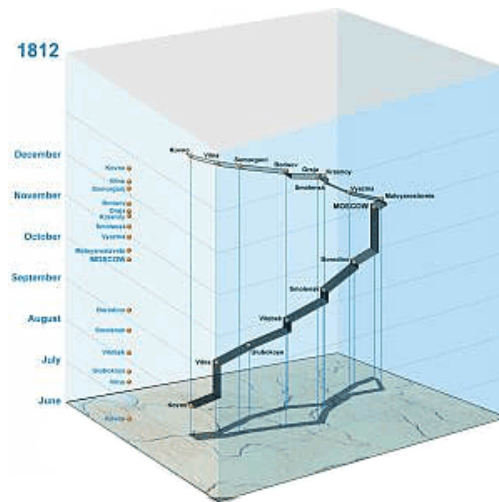


Figure 2.2: Visualization of spatio-temporal data (events) using the Space-Time Cube. Events following each others are connected with lines to show an object's movement. Image source: Kraak [2002]

According to Gatalsky et al. [2004], when searching for spatio-temporal patterns in the data, we need an overall view of both space and time. 2D visualization techniques can not provide such an overview of time. They either show only a portion of the data at single time, or display all events on a single map and therefore need labels or other indications (e.g., color) for an event's occurrence in time.

An empirical study directed by Kristensson et al. [2009] showed that the STC does indeed provide such overview of both space and time. Still, novice users have difficulties answering "simple" questions such "Are two persons at the same place at 9:00?" using the STC. But response time to answer questions that required an overall understanding of the spatio-temporal patterns were reduced from 121 seconds (for the 2D visualization) to 60 seconds (for the STC).



## Method

Needing to visualize both genealogy data and spatio-temporal data, we tried to combine the advantages of both the TimeNets visualization and the STC. We used a similar technique to TimeNets to visualize generational and temporal relationships between people, and the STC to visualize the spatio-temporal data (personal events: birth, change of location, death).

### 3.1 Space-Time Cube

The most prominent feature of our tool is the STC. It consist of a geographical map as its ground plane. The map's bounding coordinates (minimum and maximum longitudes/latitudes) are the bounding coordinates of all locations selected people have been to. The cube's height is the actual time span from the earliest event (a person's birth) to the latest event (a person's death) or, if at least one person is still alive, the current time.

There are three kinds of events: (1) birth and (2) death of a person and the (3) location-change event. The birth event is the begining of a person's *World Line* (WL), the space-time path in the STC. Consecutively, a death event is the last event in that path. If a person changes its location (e.g., moves to a different city, etc.) it's WL connects the original location with the new location with a line parallel to the ground plane (as such a movement is treated by us as an event without any duration). Figure 3.1 shows an example STC visualization of two people (female and male), where we can see the three types of events.

### 3.2 Timeline

Due to the fact, that visualizing genealogy data with a STC is not practical, we need a second view to show such a visualization. This view is called the TimeLine, which in fact is a modified TimeNets visualization. The TimeLine shows all temporal information about a selected person (date of birth, movements and death), as well as it also visualizes generational and temporal relationships of that person. A person's child is displayed as a short line below the person's own

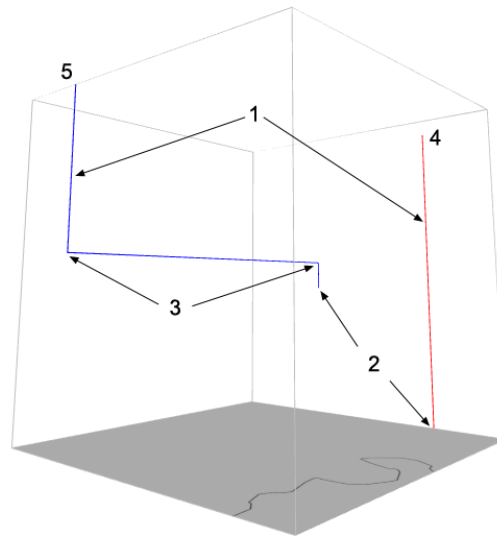


Figure 3.1: STC visualization of two people (1 red: female; 1 blue: male), showing the different kinds of events: birth (2), change of location (3) and death (4). The male person is still alive: its world line goes up to the top of the cube (5).

time line. The person's parents are indicated by similar short lines above the person's own line. This can be seen in Figure 3.2.

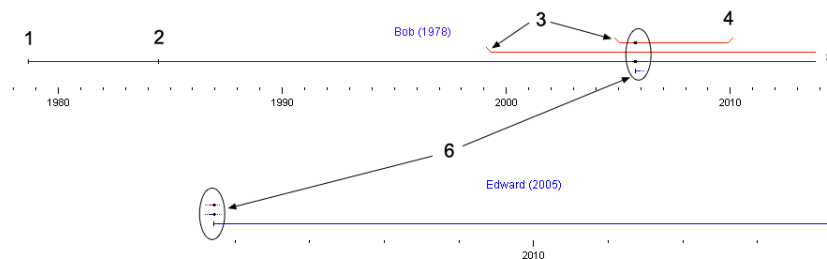


Figure 3.2: The TimeLine view shows a person's temporal information as well as visualizing its generational and temporal relationships with other people. A person's time line starts at its birth (1) and ends with the person's death or the current time (5). Change of location events (2) are indicated by small vertical ticks on the person's time line. Partnerships have at least a beginning (3) and optionally an end date (4). Bob and his second partner are parents of Edward (6). In Edward's TimeLine view (bottom) we can see how parents are visualized (6).

The TimeLine view is linked with the STC view. So, when selecting a person in one view, the other view gets updated automatically. As a consequence, if we select, for example the



child of person A in the TimeLine view by clicking on its time line, that person (the child of person A) gets highlighted in the STC view and all its information is shown in the TimeLine view. Therefore, the TimeLine view also acts as an navigation tool letting users click through the genealogical hierarchy; in both directions.

### 3.3 Interactivity

Because we use a three dimensional visualization technique, we have to take care of the problems introduced by that. An obvious problem of a 3D visualization is occlusion. For our system that is: a person's WL is partially or fully occluded by at least one other WL. This could happen in two ways. Either by having a part of a WL being "in front" of another part of the same or a different WL, or if a person shares at a specific length of time one and the same location in space with at least one other person. Occlusions of the first case can be solved by letting users rotate the STC (see Fig. 3.3).

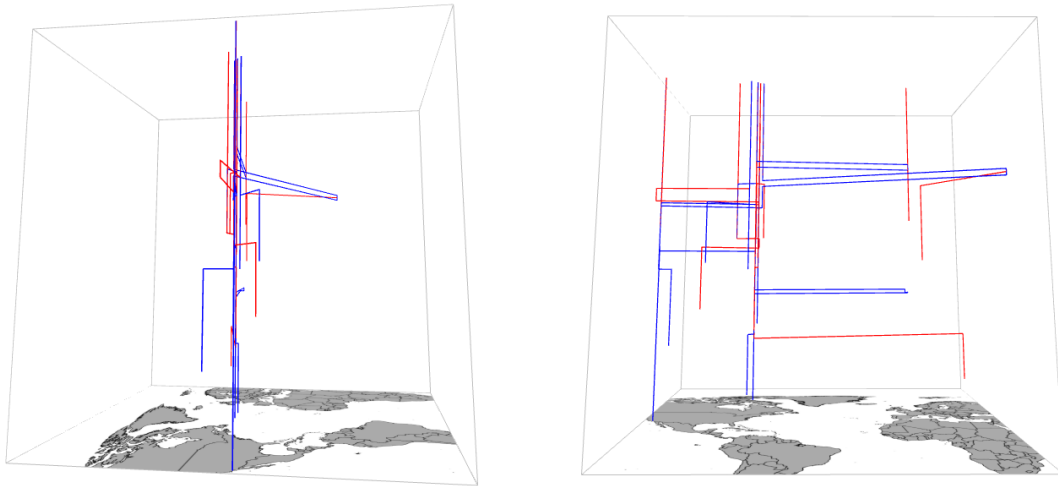


Figure 3.3: Problem of occlusion and how to solve it: left and right images show the same visualization but with a rotated STC.

To account occlusion problems of the first and second case, we introduced a special view, called the Density View. In the Density View all WLs, of both female and male people, are rendered with a single color. Additional to that, the WL's alpha value is less than one, which, in the process of rendering, will be accumulated. Therefore, with the Density View it is possible to visualize accumulations of people. We can, for example, see at which time in the past the family was strongest. Figure 3.4 shows a comparison of the normal view with the Density View.

To reduce clutter, additional information for a person is only displayed when the user selects the person by clicking the person's world line (in the STC) or its time line (in the TimeLine view)

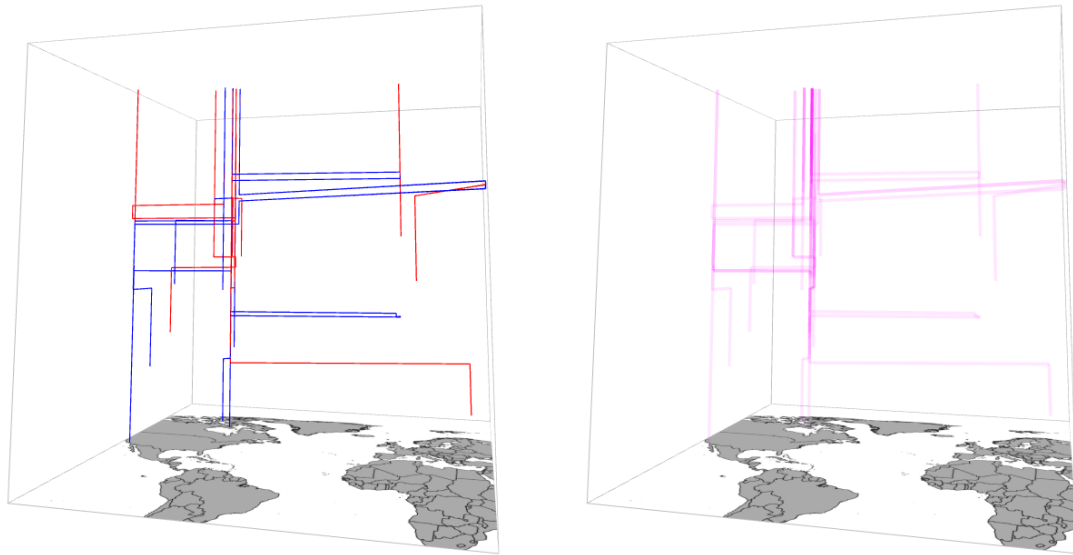


Figure 3.4: Comparison of the normal view (left) with the Density View (right). The Density View visualizes accumulations of people.

(Fig. 3.5). Also, it's possible to filter people and therefore further reducing clutter. Filtering can be done by name of a person, time (span), and places (inclusive and exclusive) (Fig. 3.6).

The STC can be zoomed, both in space and in time (Fig. 3.7). To reduce possible problems introduced by perspective distortion, projection mode for the STC can be switched between perspective and orthogonal (Fig. 3.8).

Probably the most important feature of our tool is the visualization of event clouds. Event clouds are displays of grand world events like wars, diseases, etc., which can help in finding possible causes of migration (Fig. 3.9).

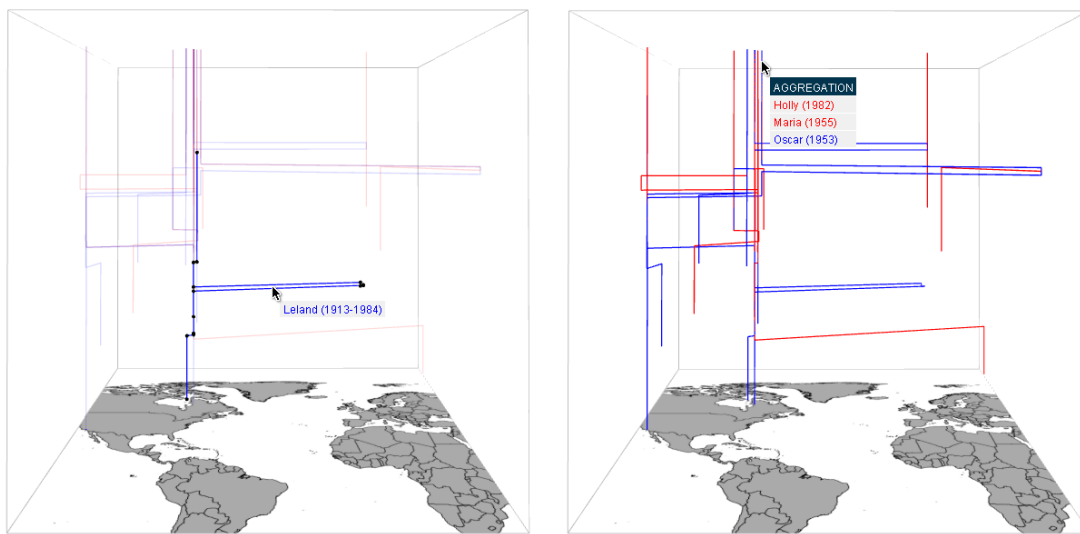


Figure 3.5: Details-on-demand: mouse-over information for single person (left) and aggregations (right).

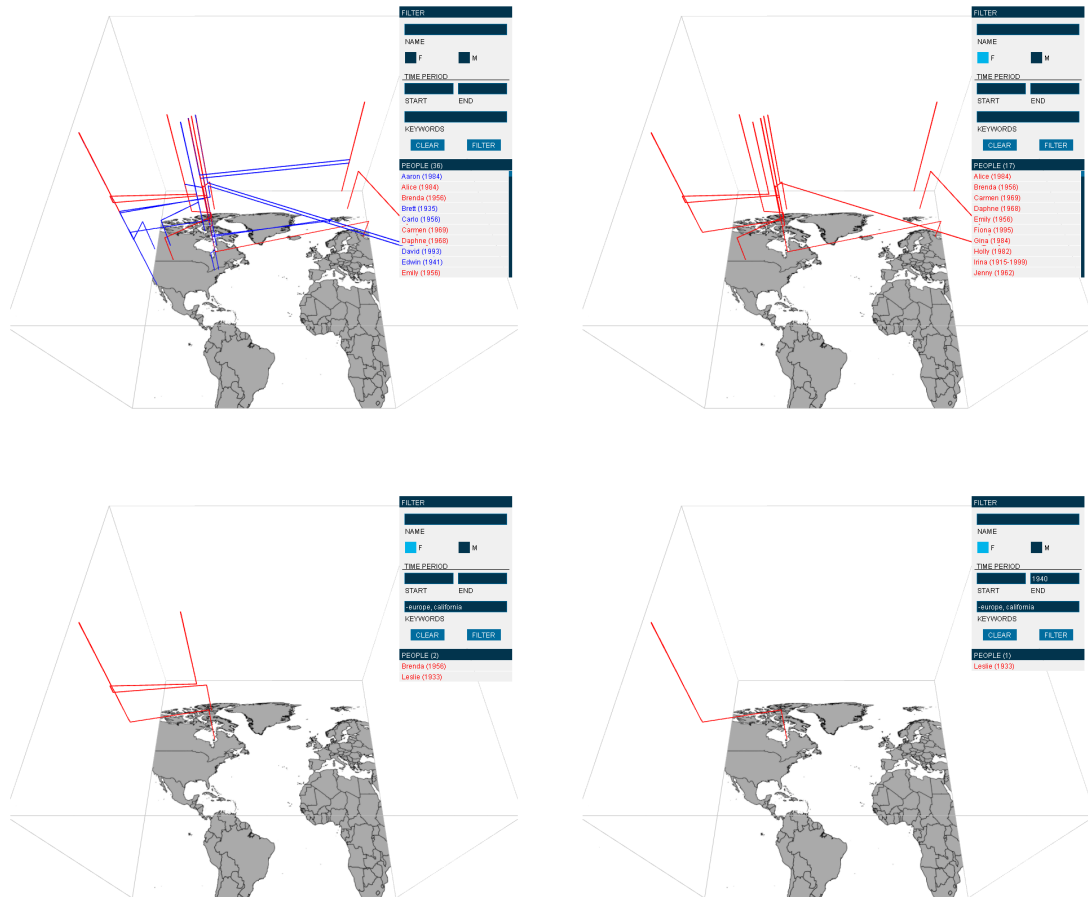


Figure 3.6: Filtering individuals by only showing female people (top right) who at least once have been in California but never in Europe (bottom left) and who were born before 1940 (bottom right).

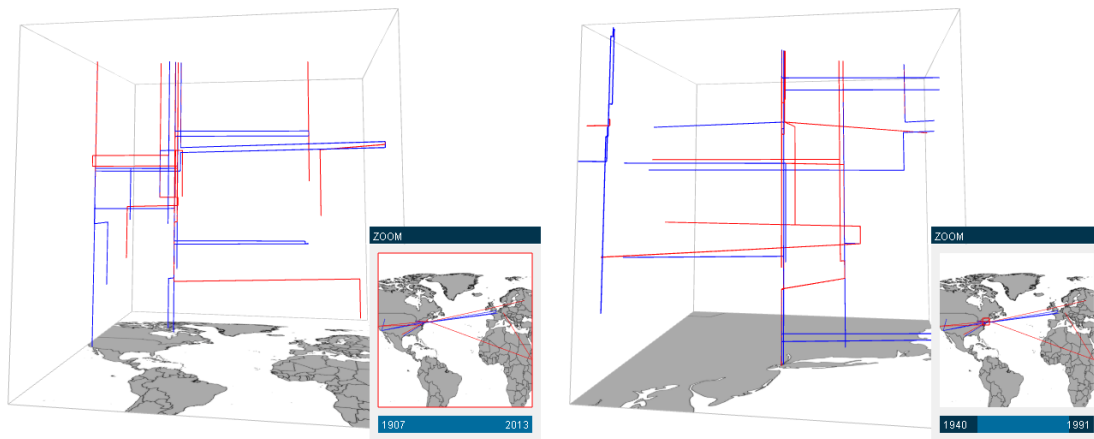


Figure 3.7: The STC can be zoomed in space and in time: the right image shows the STC if we zoom in on the New York area between 1940 and 1991.

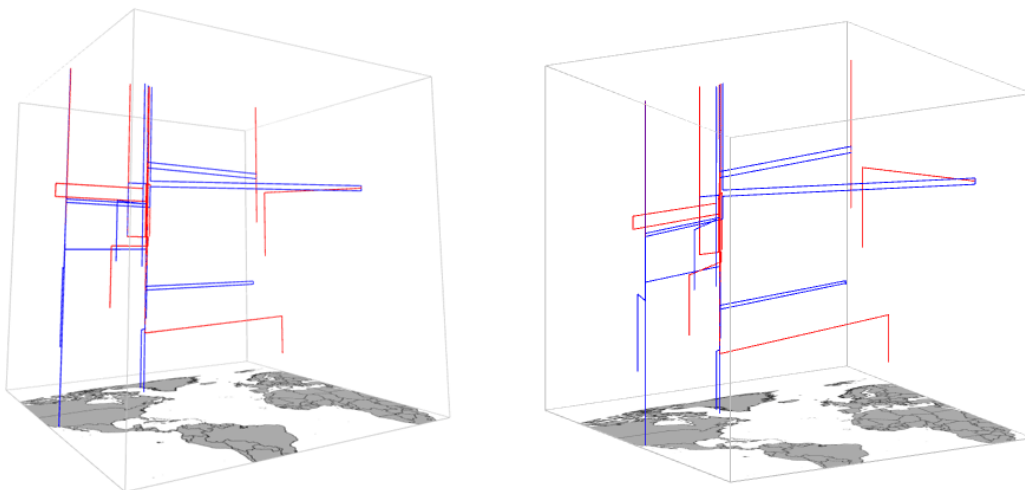


Figure 3.8: The different projections of the STC: perspective (left), and orthogonal (right).

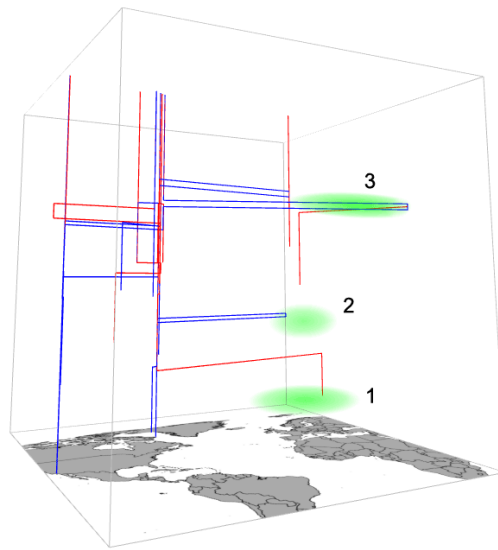


Figure 3.9: With the help of event clouds we can find possible causes of migration: Irina flew from World War I (1); Leland fought in World War II (2); Oscar and Maria met in Africa, where they both worked as medical doctors during a humanitarian crisis (3).

## Implementation

We developed our system in Java with the help of the open-source *Processing* library [Fry and Reas, 2001]. The *Processing* library provides classes and methods for generating and manipulating visual objects (e.g., lines, squares, spheres, etc.). Most user-interface (UI) elements (e.g., text input, sliders, etc.) were built using the *controlP5* library, that itself makes use of the *Processing* library.

Geographical maps are fetched from a local installation of *GeoServer* [OpenPlans, 2001], an open-source server for geospatial data. *GeoServer* publishes data from various data sources (e.g., PostGIS, MySQL, Shapefiles, etc.). The following lines of Java code produce a PNG image that can be used as the map for the STC (see Section 3.1):

```
String url = "http://localhost:8080/geoserver/wb/wms" +  
    "?service=WMS&request=GetMap&layer=" + layer +  
    "&box=" + minLon + "," + minLat + "," + maxLon + "," + maxLat +  
    "&width=" + width + "&height=" + height +  
    "&format=image/png";
```

```
PImage map = loadImage(url);
```

To input/store genealogy data, we first thought of using GEDCOM (GEnealogical Data COMMunication), a specification for exchanging genealogical data between different genealogy software. The format was developed by The Church of Jesus Christ of Latter-day Saints (LDS Church) in 1984. GEDCOM only supports data representation of temporal relationships for marriages between a man and a woman. As we wanted to also incorporate other types of relationships (e.g., same-sex marriages, domestic partnerships, cohabitation, polyamory, polygamy, etc.), the idea was dropped in favor of a custom XML (Extensible Markup Language) format.

A person basically has an identifier (ID), a name, gender, and several event tags. An event consists of a date/time, a location (longitude and latitude) and optional keywords. The keywords are used for searching and filtering. The chronologically first event of a person is treated as its birth event. All successive events (with the exception of the “death” event) are treated as change

of location. If parents are known, we can also encode them in the XML file. Figures 4.1 shows how the data is being visualized in the STC.

A partnership (e.g., friendship, domestic partnership, cohabitation, marriage, etc.) exists between exactly two people. Such a partnership has a beginning and optionally an end date. With our approach, multiple partnerships between different people at the same time can be displayed (Fig. 4.2).

```
<people>
  <person id="1" name="Alice" sex="f">
    <events>
      <event date="1950-10-08"
        lon="16.3815" lat="48.2087"
        keywords="vienna, austria, europe" />
      <event type="death" date="2010-11-18"
        lon="16.3815" lat="48.2087"
        keywords="vienna, austria, europe" />
    </events>
  </person>
  <person id="2" name="Bob" sex="m">
    <events>
      <event date="1978-07-23"
        lon="15.6395" lat="48.1937"
        keywords="st. pölten, lower austria (NÖ), austria, europe" />
      <event date="1984-05-13"
        lon="15.4518" lat="47.0538"
        keywords="graz, styria, austria, europe" />
    </events>
  </person>
</people>
```

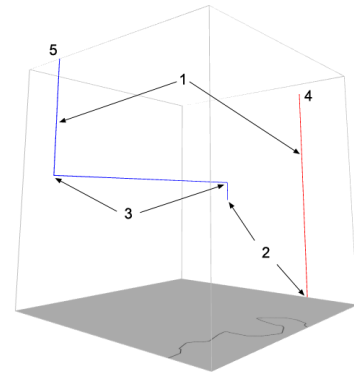


Figure 4.1: Explanation of how people and their events are being visualized in the STC. We can see World Lines (1) for person “Alice” (red) and “Bob” (blue). The chronologically first event of a person is treated as its birth event (2). All successive events (with the exception of the “death” event) are treated as change of location events (movement). The original and the new location are both visualized at the same time in the STC (3): the line connecting the two locations is parallel to the ground plane. Alice died a few years ago (4). This is encoded as a “death” event in the XML. Bob is still alive (5): his WL goes up to the top of the STC.



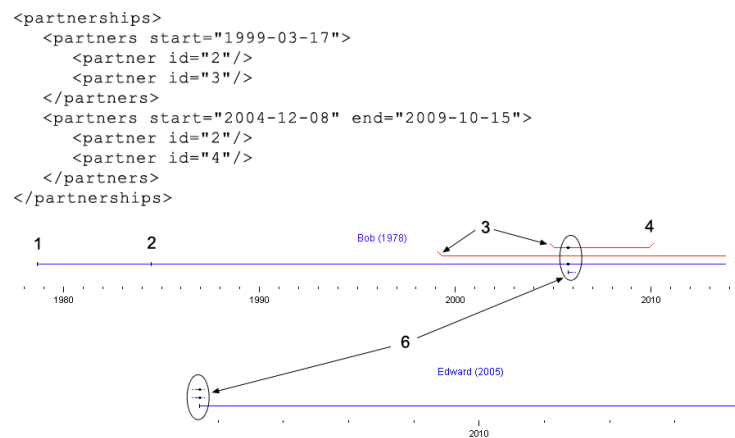


Figure 4.2: Explanation of how people and their relationships are being visualized in the Time-Line view. A person's time line starts at its birth (1) and ends with the person's death or the current time (5). Change of location events (2) are indicated by small vertical ticks on the person's time line. Partnerships have at least a beginning (3) and optionally an end date (4). Bob and his second partner are parents of Edward (6). In Edward's TimeLine view (bottom) we can see how parents are visualized (6).



## Results & Discussion

We tried to develop a tool which could help in better understanding an individual's life as well as getting an geographical overview of the whole family (Fig. 5.1). Understanding an individual's life could happen by actually seeing it in form of its world line, or by finding geographical patterns and connections between other people and/or grand world events (Fig. 5.2).



Figure 5.1: The top view of the STC provides a geographical overview of the whole family.

As traditional genealogy visualization techniques, as well as TimeNets, visualize genealogy data without any special focus on geographical aspects of individual lives, we can not really compare these techniques/tools with ours. To point out the differences and advantages of individual techniques/tools we used the same (imaginary) family for all visualizations. The family

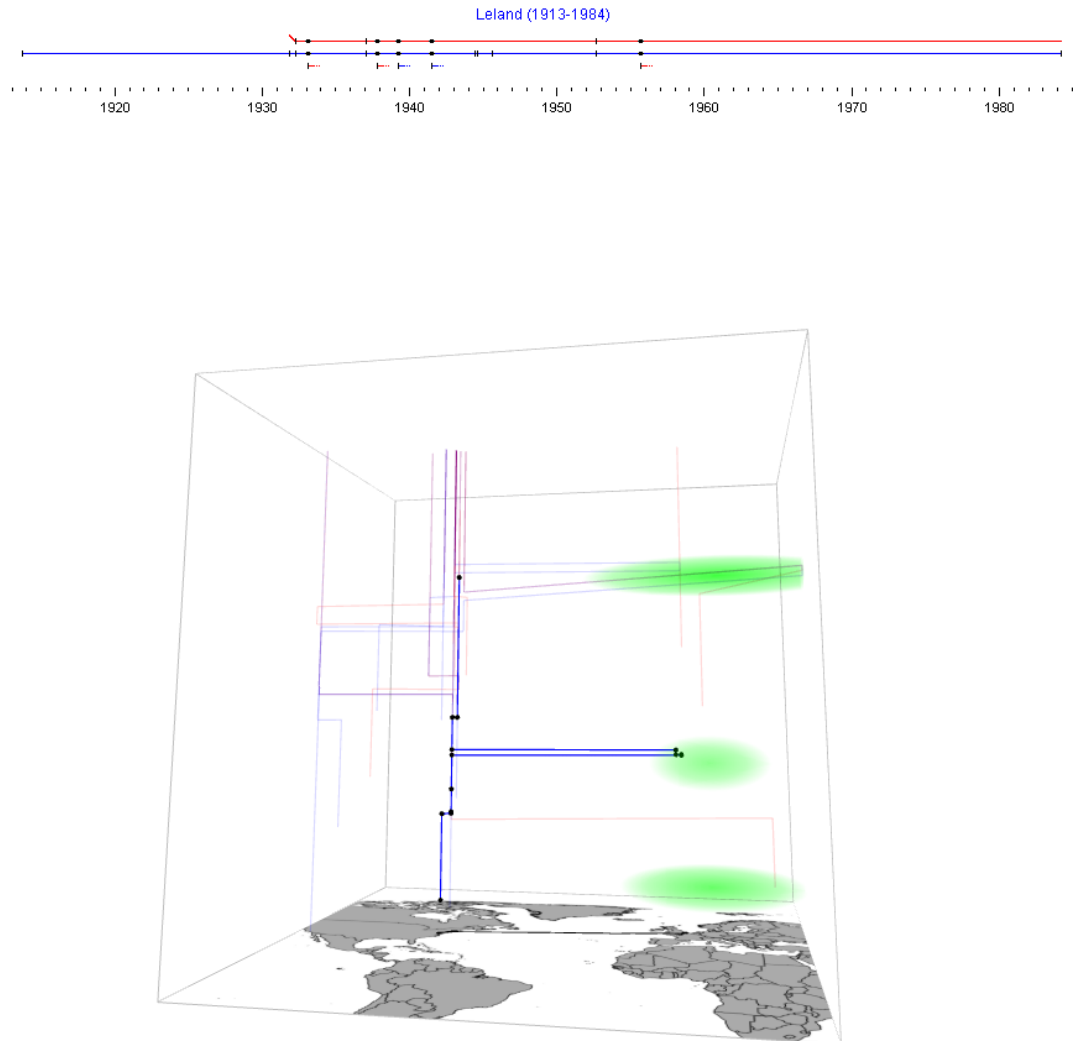


Figure 5.2: In the STC (bottom) we can see an individual in the context of the whole family as well as with grand world events. The TimeLine view (top) shows a single person's generational and temporal relationships.

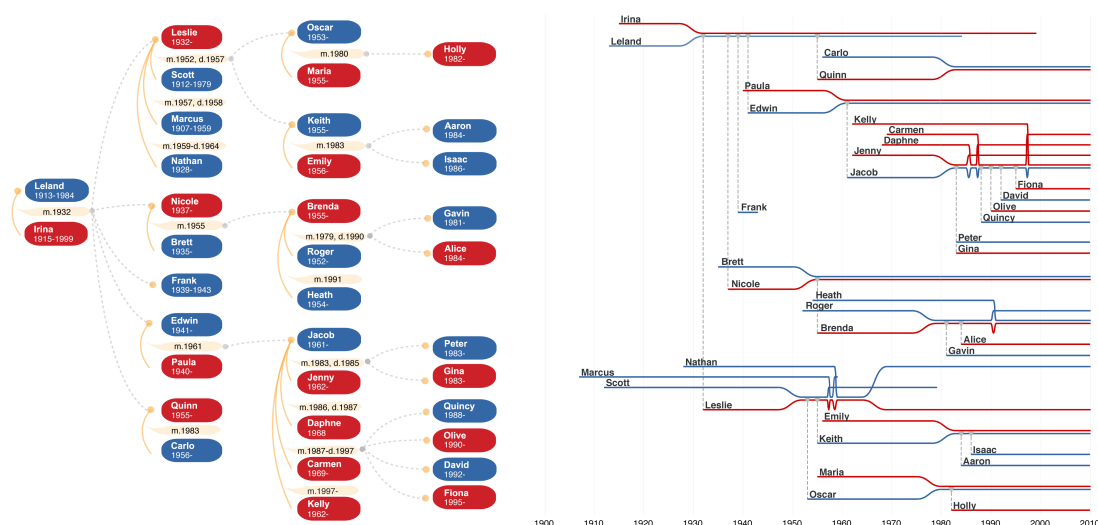


Figure 5.3: Comparison of an adapted descendant chart (left) and TimeNets visualization (right). The descendant chart shows all the descendants of Leland and Irina [Kim et al., 2010]. Generational relationships are indicated by dashed lines. Temporal relationships (solid lines) are labeled with their beginning and optional end dates. In the TimeNet visualization lifelines represent people, converging lines signify marriage, and drop lines indicate children. Image sources: Kim et al. [2010]

was introduced by Kim et al. [2010] in their paper about TimeNets. All we did was to add some historical and geographical data (places of birth/death and movements).

The descendant chart, as a representant for traditional genealogy visualization techniques, is good at visualizing generational relationships. We can clearly see who's the child of whom (Fig. 5.3, left). TimeNets is trying to also visualize temporal attributes of a person. In Figure 5.3 (right) we can actually *see* when and how long a person has lived, which people else were alive at the same time, and all (relevant) temporal relationships a person had. In the descendant chart and the TimeNets visualization the whole *genealogy* network is visualized (Fig. 5.3), whether in our tool we show the *geographical* context as a whole and only showing a single person's generational and temporal relationships (Fig. 5.2).



## Conclusion & Future Work

We provide a tool for users to geographically explore family trees and find patterns in the movement of (a single or groups of) individuals. Possible connections between movement and grand world events (e.g., wars, diseases, etc.) can be found. If the user just needs to learn/see the generational relationships of a family a traditional genealogy visualization is clearly the better choice. When temporal attributes of individuals are one's main interest she/he should consider using TimeNets. TimeNets visualizes both generational relationships and temporal attributes. But when it comes to actually be able to see a person's life, where she/he was born and grew up, where two people have met, and so on, we need a tool that shows us all this information.

We expect to enhance our tool with similarity measures, to be able to select a single person and then get a list of people having some similarities with the selected one, or to implement degree-of-interest techniques which could help in further reduce clutter by only showing people the user might be interested in. Also it would be very helpful for any future user of our tool, if we would instead of only showing current administrative borders, show historic maps as well. It might also be helpful for us to expand our tool to the web, to get more input: both from user's (to learn how they use our tool) and genealogical data as well.





# Bibliography

- C. Barlow. *Tikanga whakaaro: key concepts in Māori culture*. Oxford University Press, 1994.
- Ben Fry and Casey Reas. Processing.org, 2001. URL <http://processing.org/>.
- Peter Gatalsky, Natalia Andrienko, and Gennady Andrienko. Interactive analysis of event data using space-time cube. In *Proceedings of the Eight International Conference on Information Visualisation (IV'04)*, pages 145–152. IEEE Computer Society, 2004.
- Torsten Hägerstrand. What about people in regional science? *Papers of the Regional Science Association*, 24(1):6–21, 1970.
- Eduard Heydenreich, Otto Freiherr von Dungern, Otto Forst-Battaglia, Karge, Mucke, K. Robert Sommer, and Armin Tille. *Handbuch der Praktischen Genealogie*, volume 1. H. A. Ludwig Degener, 2 edition, 1913.
- Instituto dos Registos e Notariado. Composição do nome, November 2013. URL [http://www.irn.mj.pt/IRN/sections/irn/a\\_registral/registo-civil/docs-do-civil/dar-o-nome/](http://www.irn.mj.pt/IRN/sections/irn/a_registral/registo-civil/docs-do-civil/dar-o-nome/).
- Nam Wook Kim, Stuart K. Card, and Jeffrey Heer. Tracing genealogical data with TimeNets. In *Proceedings of the Ninth International Working Conference on Advanced Visual Interfaces (AVI'10)*, pages 241–248. ACM, 2010.
- Menno-Jan Kraak. Geovisualization and minard's map, 2002. URL <http://www.itc.nl/personal/kraak/1812/>.
- Per Ola Kristensson, Nils Dahlbäck, Daniel Anundi, Marius Björnstad, Hanna Gillberg, Jonas Haraldsson, Ingrid Mårtensson, Mathias Nordvall, and Josefine Ståhl. An evaluation of space time cube representation of spatiotemporal patterns. *Transactions on Visualization and Computer Graphics*, 15(4):696–702, July/August 2009.
- Bo Lenntrop. Time-geography - at the end of its beginning. *GeoJournal*, 48(3):155–158, 1999.
- Elizabeth Shown Mills. Genealogy in the "information age": History's new frontier? *National Genealogical Society Quarterly*, 91:260–277, December 2003.
- OpenPlans. Geoserver, 2001. URL <http://geoserver.org/>.