Visualize Overijssel's past

Interactive animation's on the WWW

(see also www.itc.nl/~kraak/overijssel)

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Introduction

Simple questions are not always as innocent as they might seem. This paper is the result of such on a simple question: "How to visualize the changing municipal population of the province of Overijssel, the Netherlands, during the last two centuries on the WWW?". After giving the question some thought one will realize that even from a traditional mapping perspective this question is not an easy one to answer. The web environment puts some obviously additional constraints to these problems: the solution has to be interactive and dynamic, while a relatively low direct information content should guarantee smooth data transfer. However, the web also proves to offer the most suitable environment to answer the question. The WWW is an accepted medium to be used for the dissemination and presentation of geospatial data. The interactive and dynamic nature of the WWW guarantees that the map in its “traditional” role can be informative and attractive for the new map user, while the available functionality supports a solution to the above problem.

In solving the question one has to deal with changes in each of spatial data’s components (location, attribute and time) simultaneously. Over time the municipal boundaries have changed, and the population numbers changed as well. In respect to each of the components problems exist. For instance one has to deal with gaps in the available statistical data. This could mean that data for a particular year is missing or that for a certain year data for a few municipalities only are missing. Not only one has to visualize those changes but also inform the viewer on the quality of these changes. In the anticipated animation environment this will put additional constraints on the map design and interface options.

The solution to the problem is a web-based animation environment. In such environment users should be able to select their own set of time-slices to be animated, while special web maps linked to a time-slice can be created to highlight problems with both the location as well as attribute data. Among the functionality required are options to animate the data’s location or attribute component individually. At any time the user should be able to identify a geographic unit and be informed on its attribute data. The animation could be accompanied with alternative linked graphics to clarify some particular problems or highlight changes.

The environment and functionality described relies heavily on recent developments in geovisualization. Geovisualization integrates approaches from visualization in scientific computing, cartography, image analysis, information visualization, exploratory data analysis, and geographic information systems (MacEachren and Kraak, 2001). Here maps are used to stimulate (visual) thinking about geospatial patterns, relationships and trends. It stimulates to view geospatial data sets in number of alternative ways using multiple representations with out constraints (traditions).

Finding data on boundary and population changes

Municipalities as we know them today came into being in the period of Napoleonic rule in the Netherlands. During that period French law was introduced in the country. This resulted in a dramatic change of local boundaries. For instance, provinces (departments) were all bounded by rivers, which resulted in changes with the neighbouring provinces. Before Napoleonic rule Overijssel consisted of “Richteramten” and “Schoutamten” further subdivided in “Marken”. In 1811 these all changed in “Marieën”. In 1818 several years after their departure many boundaries create by the French where restored to their original location. From that period on the Dutch word for municipality (in French Marie) “gemeente” came in use. In 1811 62 municipalities existed in Overijssel. During the last decades of the 20th century many municipalities in the Netherlands have been merged one way or the other for administrative efficiency. In 2001 Overijssel had only 26 municipalities left (Hendrikx, Holsheimer-Wezeman *et al.*, 2000). Figure 1 shows the situation in 1811 and in 2001. The figure’s inset shows an overlay of all boundaries situations for the northwest during that period.

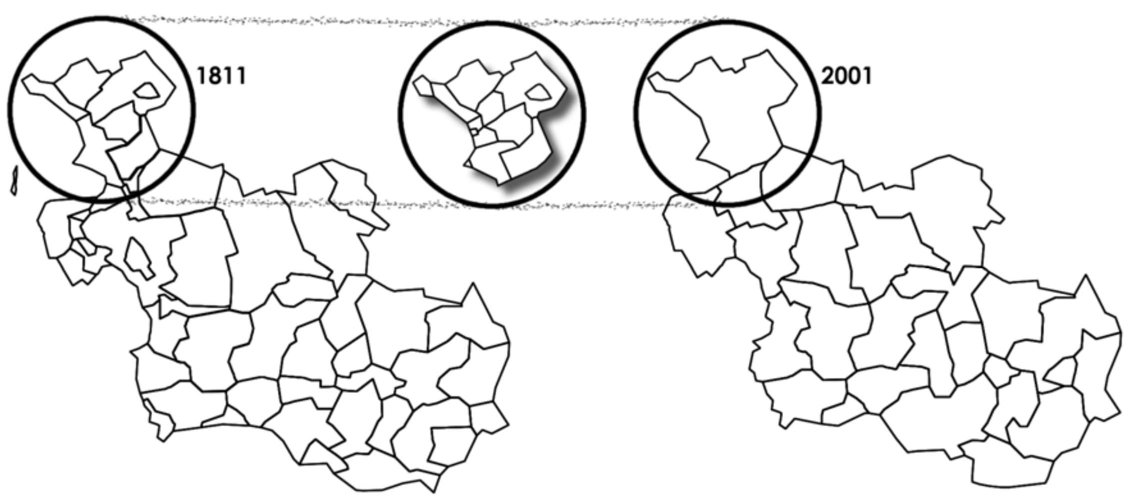

Figure 1. What has been collected? Boundary changes between 1811 (a) and 2001 (b). An overlay of all changes has been produced (c).

For the collection of boundary information we depended on maps and publications. Most changes after 1900 are documented on topographic maps, that is, if the boundaries did not change twice in the update cycle of the maps. Before 1900 the number of changes was limited. Some small-scale maps exist and the changes have been described in, sometimes conflicting publications. Cadastral sources from 1830 and later could also have been used. However, it was decided not to do so, because the tremendous archive research work involved would not be reflected in the final product, an interactive map on a scale of about 1:500 000 in a geovisualization environment. The governmental paper “Staatscourant” has publish every change in the municipal boundaries, and recently these are published on the WWW *[URL 1]*. In other disciplines researchers have been active collecting similar data. However, most publications contain lists that verbally report on changes, like “Enschede lost 50ha to Hengelo (100 inhabitants involved)”. However in most cases there is no reference to more detailed information, let alone the location of boundaries (Hendriks, 1960; Waltmans, 1994; Beekink and Ekamper, 1999).

GEMNR	GEMNAME	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	189
1009	ALMELO, AMBT	7355	7538	4011	4025	4156	4171	4195	4329	4485	4675	4854	4998	503
1189	ALMELO, STAD	4132	4128	7758	7826	7836	7706	7770	8090	8101	8078	8091	8201	826
141	ALMELO													
143	AVEREEST	6379	6466	6532	6573	6569	6549	6600	6577	6644	6684	6644	6666	634
144	BATHMEN	1572	1596	1405	1375	1403	1403	1368	1392	1383	1408	1384	1356	136
145	BLANKENHAM	525	524	518	510	507	508	504	508	543	539	554	524	52
146	BLOKZIJL	1618	1626	1630	1643	1648	1626	1608	1582	1610	1591	1559	1561	158
146	BORNE	4225	4277	3967	3952	4019	4083	4117	4149	4197	4223	4265	4319	445
194	BREDERWIEDE													
148	DALFSEN	5181	5225	5306	5226	5299	5224	5207	5403	5340	5382	5322	5348	530
142	DELDEN, AMBT	3082	3075	3001	3008	2977	2987	3010	2996	2994	2975	2974	2965	291
179	DELDEN, STAD	1690	1683	1699	1693	1703	1694	1710	1739	1761	1752	1754	1755	175
	DELDEN													
159	DEN HAM	4364	4388	4420	4490	4455	4366	4301	4311	4385	4383	4449	4375	447
149	DENEKAMP	4137	4107	3995	3949	3886	3879	3825	3837	3807	3897	3916	3823	389
150	DEVENTER	19069	19408	19162	19634	20230	20578	21028	21535	22068	22449	22700	22919	2291
151	DIEPENHEIM	1684	1728	1674	1650	1595	1597	1615	1567	1581	1608	1605	1597	156
152	DIEPENVEEN	3749	3771	3687	3746	3776	3794	3805	3792	3903	3869	3925	3860	386
153	ENSCHEDE	5674	5630	5450	5540	5645	5667	5801	12700	13353	13749	14227	14721	1522
154	GENEMUIDEN	2667	2735	2827	2858	2868	2862	2876	2893	2908	2911	2891	2882	288
155	GIETHOORN	1845	1866	1890	1895	1858	1874	1882	1913	1915	1924	1962	1945	195
156	GOOR	2359	2397	2467	2514	2543	2612	2609	2584	2654	2664	2730	2808	284
1065	GRAFHORST	636	635	636	622	628	625	628	646	677	673	646	655	62
157	GRAMSBERGEN	3134	3123	3194	3207	3323	3291	3275	3322	3298	3345	3415	3369	338
158	HAAKSBERGEN	4754	4796	4895	4856	4785	4809	4797	4867	4871	4896	4942	4948	487
1011	HARDENBERG, AMBT	7629	7811	8040	8154	8175	8151	8225	8232	8322	8415	8460	8497	817
1191	HARDENBERG, STAD	1373	1407	1374	1363	1352	1355	1381	1357	1362	1377	1406	1412	138
160	HARDENBERG													
161	HASSELT	2502	2540	2529	2570	2574	2550	2520	2506	2575	2551	2531	2515	245
162	HEINO	1857	1872	1966	1952	1953	2026	2019	2015	2029	2035	2053	2051	205
163	HELLENDOORN	5617	5653	5891	5795	5832	5796	5837	5964	5992	6058	6080	6140	626
164	HENGELO	6480	6686	6502	6603	7459	7644	8018	8447	8671	9211	9476	9857	1026
165	HOLTEN	3003	2979	2949	2963	2941	2913	2919	2867	2843	2863	2893	2858	278
195	IJSSELHAM													
191	IJSSELMUIDEN	1917	2026	2086	2080	2113	2118	2120	2117	2071	2135	2133	2136	215
166	KAMPEN	17245	17530	17444	17849	17770	18065	18276	18288	18438	18699	18703	18767	1868
1092	KAMPERVEEN	669	688	673	667	678	658	644	654	650	656	653	681	67

Figure 2. What has been collected? Absolute population per year per municipality from 1811-2001.

Population statistics were also gathered from different sources. For recent data one could rely on the Statistics Netherland (Centraal Bureau voor Statistiek). It’s website *[URL 2]* and publications offered data back until about 1940. Census data (every ten year until 1971) were available. Individual municipalities also offered statistics. Some very limited, others as far back to 1840. Archives and geographic dictionaries were consulted as well. Again researchers had worked on preparing similar datasets. For the period 1851 and 1940 (Knippenberg and Mathijse, 1990) had created a “Historical-Ecological Database” with all kind of variables reflecting the political and social characteristics of Dutch municipalities. For the period 1811-1840 the Netherlands Interdisciplinary Demographic Institute maintains the Hofstee-database. This database contains population statistics for all Dutch municipalities for that period. (Beekink and Cruyningen, 1995) describe the characteristics of this database. From these different sources the relevant data for the municipalities of the province of Overijssel was merged into a single spreadsheet. Due to this effort the number of inhabitant for each year in between 1811 and 2001 is known for every municipality that ever existed in the province (see Figure 2). However, due to the nature of the data source and possibility of making mistakes while creating the spreadsheet diagrams of each municipality have been created as check plots. Figure 3 displays such a plot for the municipality of Enschede. It immediately reveals an error for 1978 were a digit was missing resulting in extreme low value. Interestingly enough two other clear changes in the curve elicit curiosity. Studying those dates close revealed that these abrupt increases corresponded with the annexation of part s of neighbouring municipalities. This proves the strength of combined and alternative linked graphics in exploring geospatial datasets.

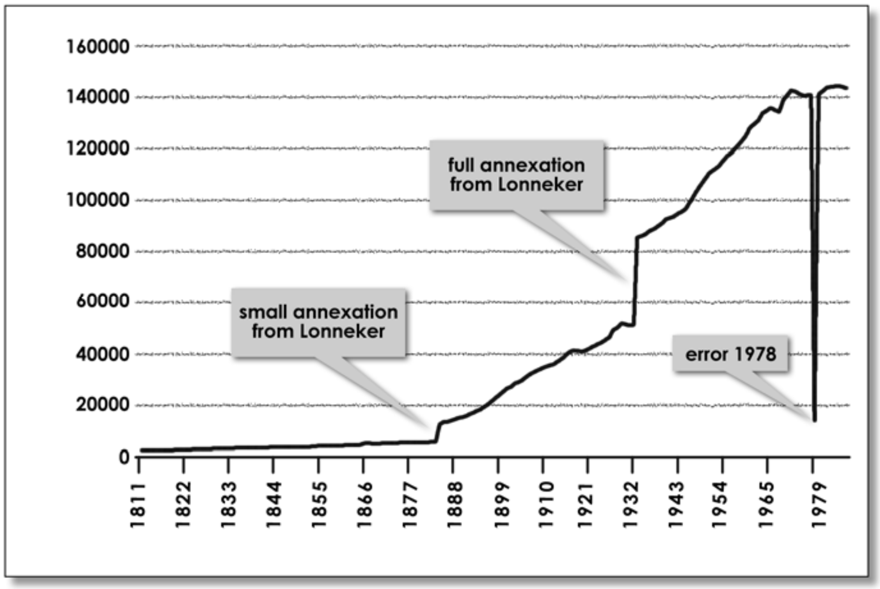

Figure 3. Data verification. The use of diagrams to check the consistency of the population data collected. The Enschede population-diagram reveals some boundary changes and an error in the data.

When found, organizing the population data is straightforward. However, the boundary requires more attention. If municipalities split of merge the results are clear. When only relatively small changes take place the question is when is a change significant. Since we aim at map scale of around 1:500.000 it is oblivious that when only a few parcels change over from one municipality to the other they change can be ignored. It was decided only to consider changes that affected more then 5 square kilometers. But is that correct? What if an area smaller then the threshold involved many inhabitants? Then the change becomes significant – the population curve will show a clear change in orientation. Consequently it was decided that irrespective of the size of the area, when more then 500 inhabitants would be involved in the change it would be recorded. This still is no guarantee for success, because how to deal with cumulative changes just below the threshold? Since the end this might have a dramatic impact, these changes were recorded at when thought appropriate changes were executed. In the current data set only one such situation is known.

Visualization options
Before some mapping suggestions are elaborated it is good to remember the final visualization should show the number of inhabitants for a municipality in a particular year. Users should be informed about the year, inhabitants and name of municipality.

If one has to find a mapping solution for a single snapshot in time the answer can be rather straightforward. Dealing with absolute quantitative data per municipality for a single year would in most cases result in a proportional dot symbol map. Alternatives could be contiguous or pseudo-contiguous cartograms, or prism maps (Dougenik, Chrisman *et al.*, 1985; Dorling, 1995) (Slocum, 1998).

Temporal changes in attribute value only are not necessarily problematic. As long as the geometry is not changing as well a diagram map could be used when al data has to be displayed in a single map. Alternatively multiple maps or an animation of a proportional dot symbol map, or the above mentioned alternatives can be used to display population increase or decrease. Interactive could be realized with brushing techniques and linked views (Dykes, 1998; Andrienko and Andrienko, 1999).

Temporal changes in geometry only can also be accommodated in a single map if not to many. Animation is a good alternative, however if interactivity is more then showing the previous or next set of frames special attention has the be given to the underlying data structure to accommodate the queries. (Boonstra, 1990) describe NLKAART, a programme that, based on a particular query can create maps for the year selected moment in time, however interaction is limited to compose the query. A more flexible solution is illustrated by Clockwork Software, who developed Centennia *[URL 3]*, an interactive animated electronic atlas that shows the boundary changes of Europe during the last millennium.

The problem of the 1811-2001 Overijssel data set is that it includes many boundary changes and mergers of municipalities, as well as population increase and decrease. How can this be combined? Using a proportional dot symbol map could result in a restless view with symbols moving, popping up etc. due to disappearing and appearing municipalities. Cartograms might suffer from the same problem, while additionally the changing shapes of the geographic units makes it even more difficult to recognize the municipalities, although more research is needed. Alternatively, a prism map, a three-dimensional representation can be the solution. The height of the geographic units represents the number of inhabitants and its colour represents the municipalities. The use of a prism map does require an interactive environment to rotate the map since some columns can hide others. In a web-environment a prism map in a VRML representation will allow for this interactivity. How does the prism map accommodate all changes? Figure 4 explains how all data have been converted in a structure that allows real time interaction in a VRML-environment.

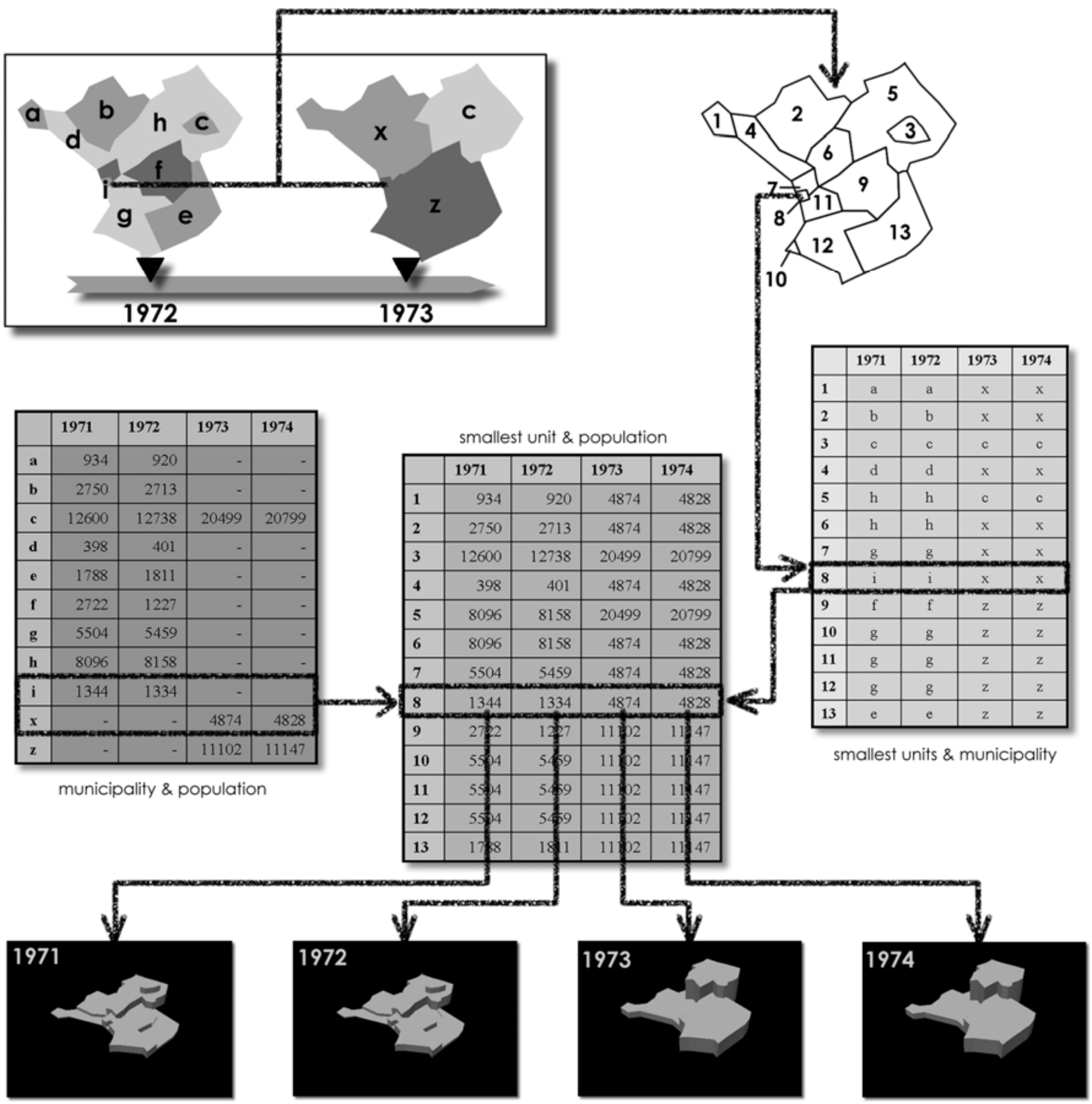

Figure 4. Preparing the data for use in a 3d-geovisualization environment. Processing the boundary information (a), processing the population data (b), display (c).

All maps of the different administrative situations that existed over the study period 1811-2001 (23 in total) have been combined and overlayed resulting in a dataset with the smallest geographic units (see figure 4 II). Based on this dataset with the smallest geographic units a look-up table has been created (figure 4-III). This table contains for each of these units for each year the code of the municipality it belonged to The figure shows a situation of change between 1972 and 1973, and we can see that smallest geographic unit *8* belong in 1971 and 1972 to municipality *i*, and after those years it belong to municipality *z*. This look-up table is combined with the spreadsheet with the population data per municipality per year (see figure 2). The result is a table with for each smallest geographic unit per year the number of inhabitant for the municipality it belonged to. From the figure it can been seen that unit *8* get the population values (1344) from *i* for the years 1971 en 1972 and from *x* (4874) for 1973 and 1974. This table is used to give the smallest geographic units their height in the prism map (see figure 4 IV). To give all municipalities their own colour the look-up table from figure 4 III is used. The above solution allows for a smooth transition from one year into the other.

Based on these results an animation has been created. It does show the population growth and gives the boundary changes as well. However, with standard animation techniques one can only interact via the media player in use. This is considered to limited. A more direct option to travel time is needed. The user should also have the ability to query the prism map to get answers to simple questions such as “What is the name of this municipality?” and “How many inhabitants does this municipality have in this particular year?” Another problem, as remarked before, is related to the three-dimensional view. It is virtually impossible to select a viewpoint that allows overview on all data over the full time period.

The above problems can be solved when the prism map can be represented in a VRML-world *[URL 4]*. Most important VRML representations can be looked at in any web browser when a necessary plug-in is available. The plug-in functionality offers tools to manipulate the prism map in three- dimensional space. The user can view Overijssel from any angle, and as such can avoid that other municipalities obscure the municipality one is interested in. A slide bar has been added, as well as the option to query the individual municipalities.

Some considerations

Although the above offers an answer to the question asked at the beginning of this paper it will be obvious that the functionality has to be extended to really provide the possibilities a geovisualization environment can offer. Examples include the option to select – highlight – a particular municipality or group of municipalities and follow them through time. Another example would be the chance to select a particular period in time and only study those years. Even more interesting would be to create linked views to the VRML world, to allow brushing to, for instance, display the population diagram for a selected municipality. Another useful function would be the possibility to click a steep part of the population diagram (see for instance 1932 in the Enschede diagram in figure 3). Following this action maps of the selected and adjacent municipalities should appear displaying the situation before and after the year selected. This might help the user to understand what caused the change. Annexations could immediately be seen. Of course not all reasons for decline or growth will emerge from the maps. This would require local knowledge of the history.

Another problem to solve is how to focus on changes? Looking at the VRML representation or the animation result is many movements all over the view due to changes in population and boundary changes. Is it possible to assist the user by highlighting changes? How useful would it be to indicate the data source for the population data (census, interpolation, municipal statistics, estimates, etc), or boundaries (map source, scale etc). Alternatively, it could be informative to emphasise the boundaries that did not changed during these years?

Although there are many questions left that need further research it has become obvious that interactive and dynamic three-dimensional visualization of geographic data changing over time increases the insight in the nature of the data and allows exploration when applied in a geovisualization environment.

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