InfoVis - Geographic Visualization

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Paper skeleton from Keith Andrews [2012]

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Abstract

GeoVis is a large topic with many different approaches, techniques and tools. In this survey the reader can get an overview over the two, probably most used map types today. These are the Choropleth Map and the Slippy Map which of course can be used together to create one Slippy Choropleth Map.
At first this survey will go a little bit back in time to the roots of the Choropleth Maps then the reader will get an overview about the classification in Choropleths. The next points are about change blindness and some tools to create Choropleth Maps. Last but not least the probably newest map type - the Slippy Map - will be explained. Slippy Maps are webmaps which allow the user to fluently navigate through the map due to an efficient loading process of the raster images - the so called tiles - which a Slippy Map consists of. A Slippy Map can be overlayed with lines, shapes and placemarks, to place user-created markings on the Slippy Map.

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Chapter 1

Choropleth Maps

The first part of this survey is about Choropleth Maps. Including a short overview explaining what a Choropleth Map is followed from their history, classification, change blindness and some tools for Choropleth generation.

1.1 General

Almost everyone has seen a Choropleth Map yet but maybe has not heard the name Choropleth yet. Therefore the first picture Fig. 1.1 shown in this survey is an example of a Choropleth Map. A Choropleth is a map where the areas are shaded according to data assigned to those areas. Furthermore they are based on stepped surfaces which means that there are no smooth transitions from one area to the next but there is a hard step between different areas showed in the colour coding.
Those maps are very popular on the election days to show which region did vote for which party. Of course there are many other cases where Choropleth Maps can be useful. In most cases there is only one value mapped to the different areas in a Choropleth but as shown later, it is possible to map two values as well in a Choropleth Map.

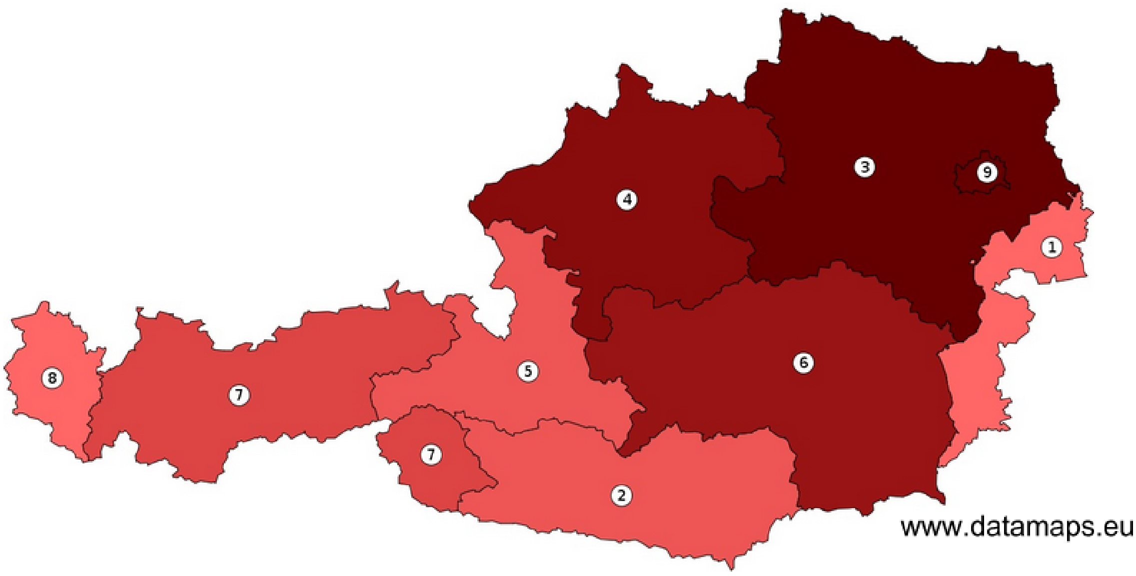

Figure 1.1: This picture was generated with the online tool from www.datamaps.eu which will be explained later in more detail. [open3, 2013]

Chapter 2

Choropleth Maps

2.1 History

The roots of the Choropleth Maps are a little bit gack in history between 1819 and 1826. At this time the first Choropleth maps were created. A few years later more of these new maps appeared but it took over one hundred years for those to be named.

2.1.1 First occurances

The first Choropleth Map did appear in the year 1819 in France. The artist of this map was Baron Charles Dupin, who was an early education reformist and tried to depict education rates around France in this first Choropleth Map. Fig. 2.1. A few years later Baron Charles Dupin made another Choropleth Map public where he did link health of the nation to education of the nation. Fig. 2.2.

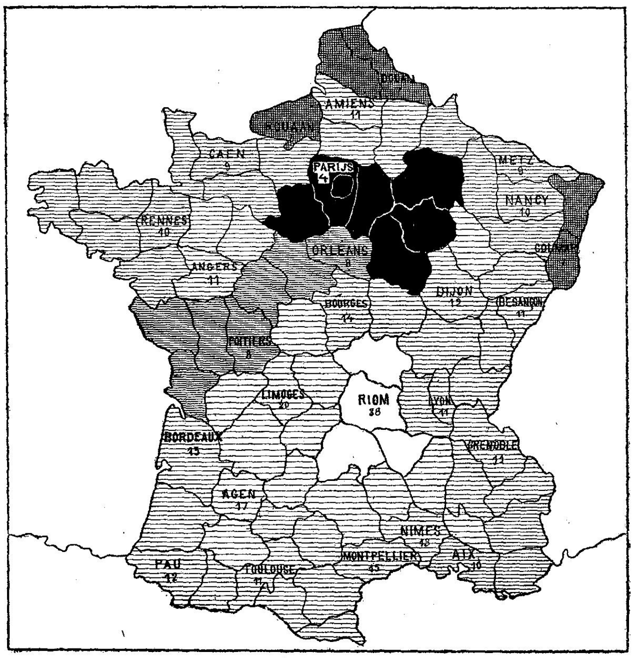

Figure 2.1: This picture shows the first Choropleth Map, dated to 1819 from Baron Charles Dupin. [Image extracted from [Dupin, 1819]]

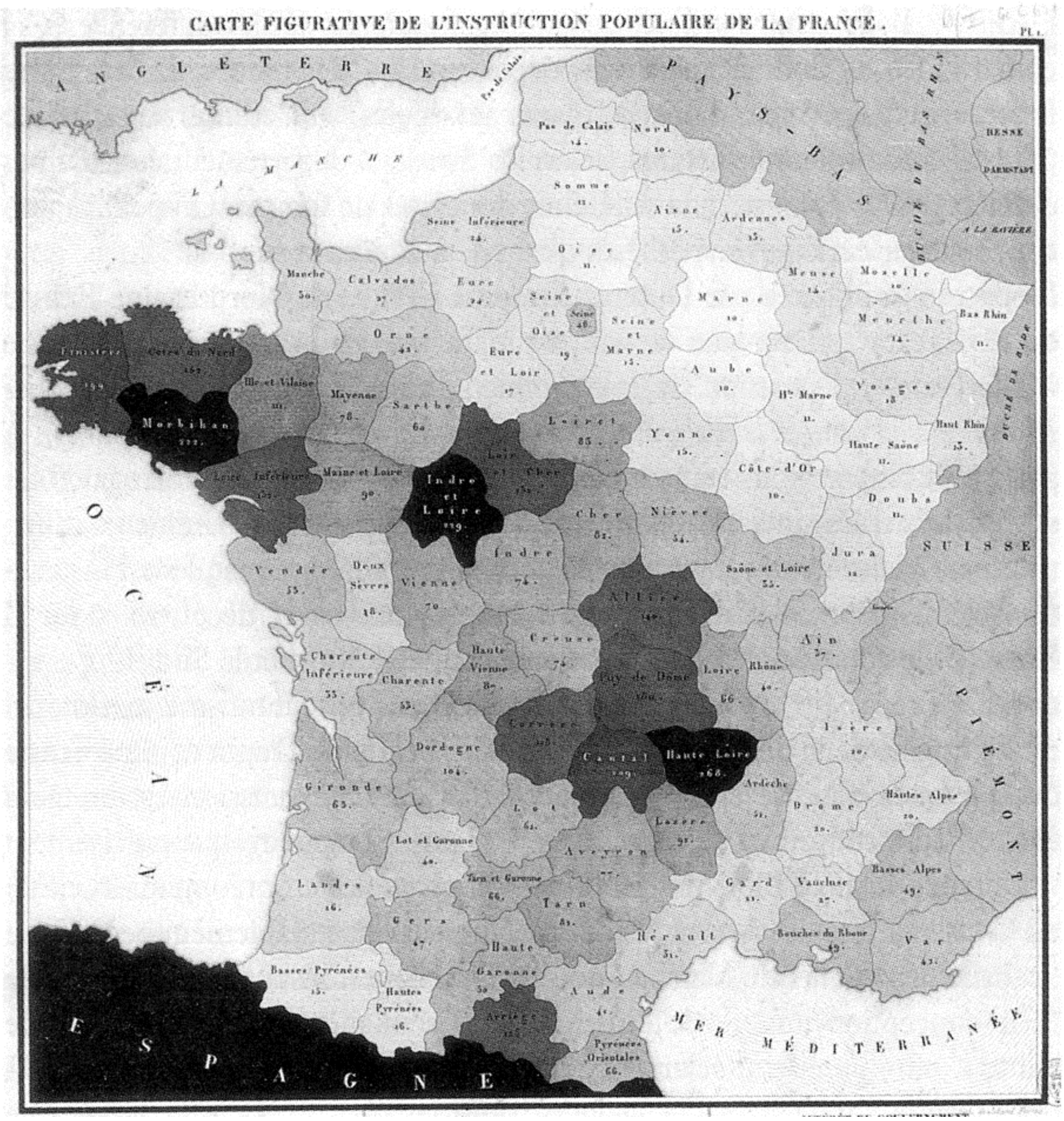

Figure 2.2: This picture shows one of the first Choropleth Maps, dated to 1826 from Baron Charles Dupin. [Image extracted from [Dupin, 1819]]

Both of these maps can be found in "Milestones in the History of Thematic Cartography, Statistical Graphics, and Data Visualization" [www.datavis.ca, 2001]. He did use shadings from black to white to create these two unclassed Choropleths and perhaps the first modern statistical maps.

2.1.2 First Comparative Choropleth maps

A few years later, in 1829, another set of Choropleths appeared in France. The authors have been Adriano Balbi and André Michel Guerry who have been political economists and not cartographers. Those maps have been the first comparative Choropleth Maps in history. The authors did compare crimes against persons and crimes against property in relation to level of education by departments of France. They wanted to show where problems are in the country with these maps. Fig. 2.3.

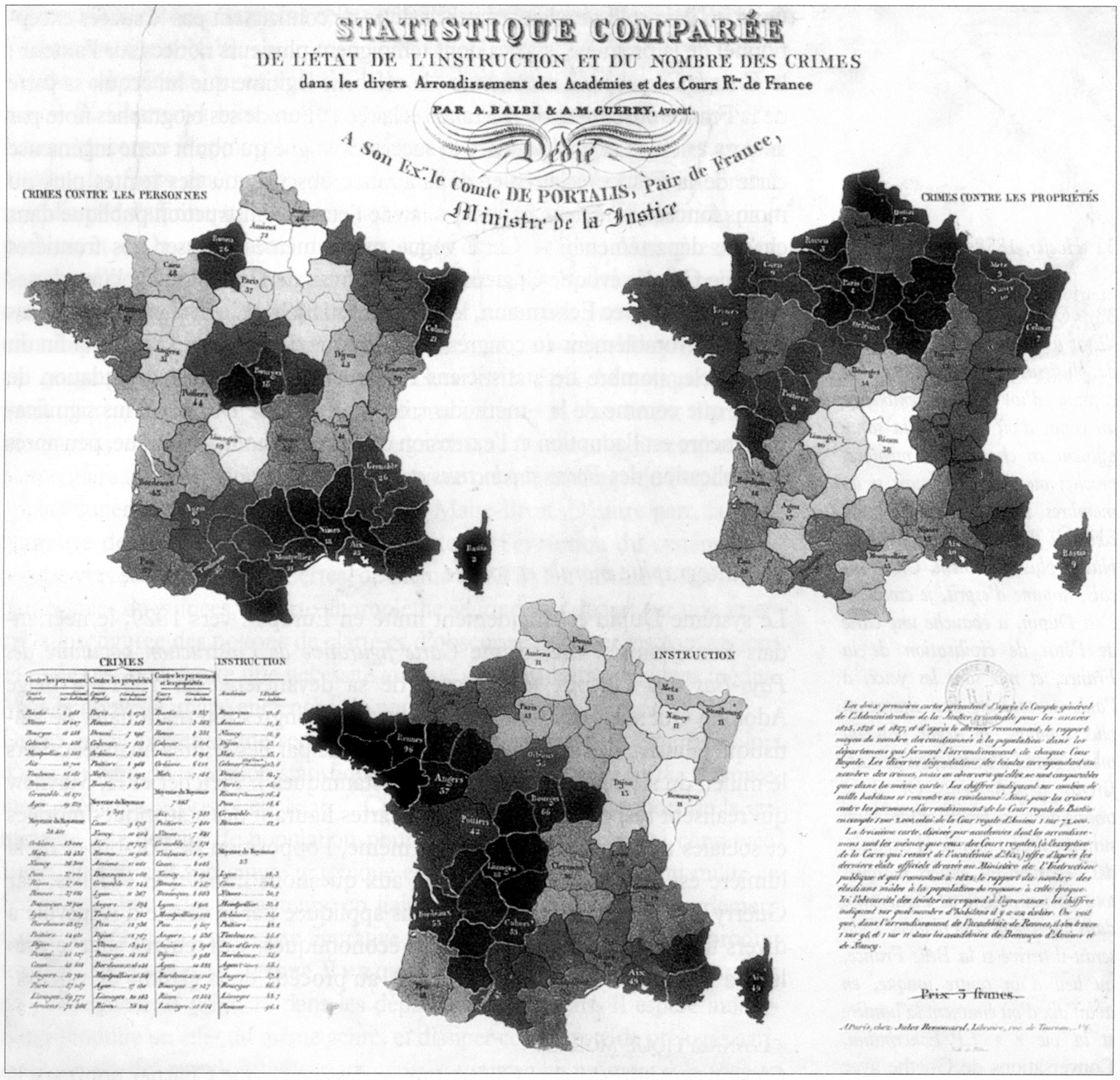

Figure 2.3: This picture shows one of the first Choropleth Maps, dated to 1826 from Baron Charles Dupin. [Image extracted from [Friendly, 2007]]

2.1.3 Name

The name Choropleth did appear over 100 years later in 1936 in a paper from John K. Wright named "Notes on statistical mapping" (Wright, 1938). The name itself comes from the two Greek words choros meaning place and pethos meaning place. “Wright presumably based his word by analogy to the much older word isopleth, which is a line of equal quantity.” [Crampton, 2003]

2.1.4 Wrights Warning

Wright did also try to warn his readers from choropleth Maps because he did realize that they hide internal variations in large areas. He himself did favour Dasymetric Maps (Fig. 2.4) because they can capture data patterns over several regions and are more flexible in this way.

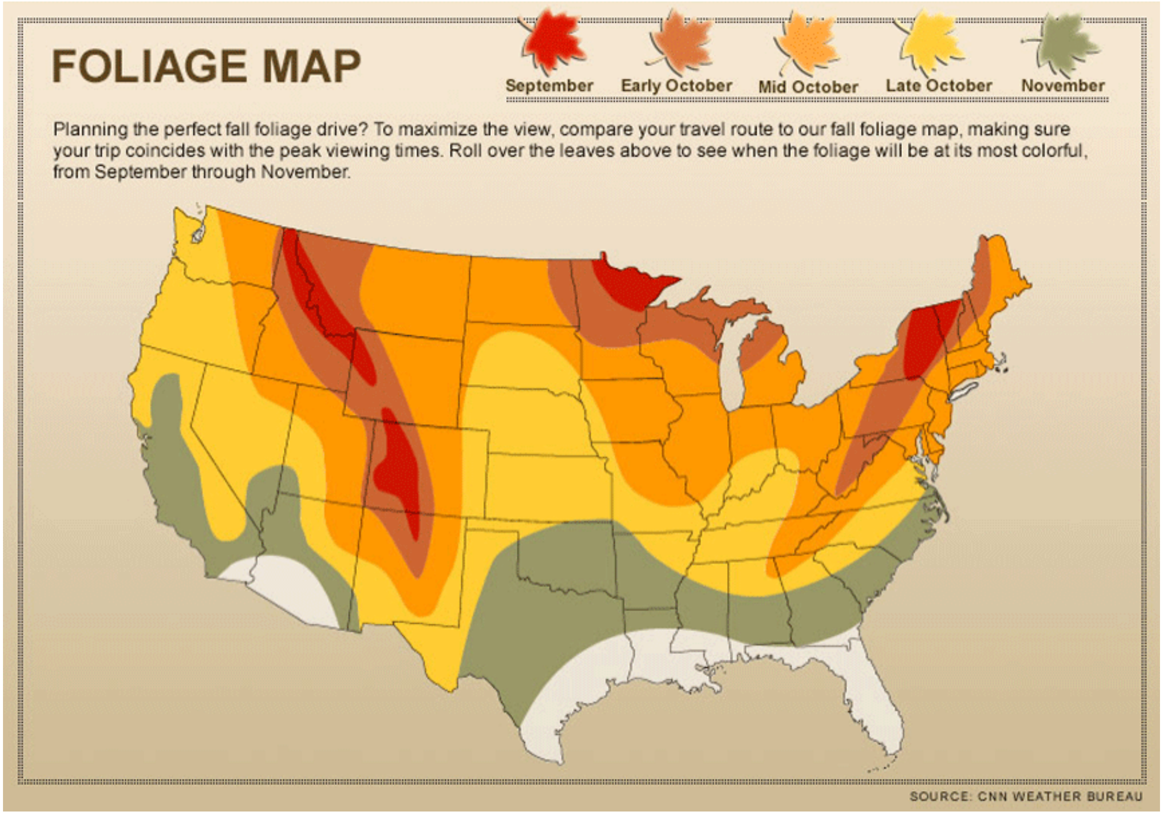

Figure 2.4: This picture shows a dasymetric map. [Image extracted from *Dasymetric Map*]

2.2 Classification

To get an effective Choropleth Map which is understandable for the viewer, the classification is crucial. The classification for Choropleth Maps can be divided into three steps:

- colour selection
- selection of the number of classes
- choice of the classification scheme

2.2.1 Colour Selection

In this step the choice of colour for the Choropleth Map is made. There are two cases to distinct between at first. Those two are the nominal scale and the ordinal scale. The difference between them is that in the ordinal scale the values can be compared to each other and it is possible to sort them on a scale from for example one to ten. In the nominal scale the values cannot be put in relation to each other but it is possible to distinct different values and group similar values together.
In the nominal scale ungraded colours or patterns (Fig. 2.5) can be used since the only goal here is to show which values belong to the same group and which belong to another group and it is important to be able to distinguish between different groups.

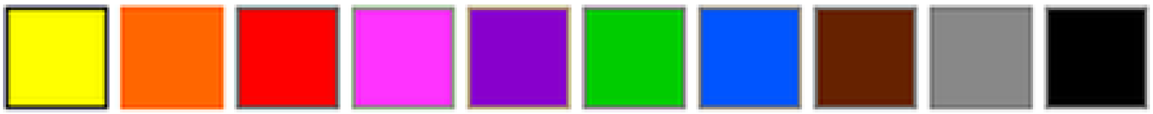

Figure 2.5: Example for ungraded colours. [Image extracted from open3, 2013]

On the other hand, if the values are in ordinal, interval or ratio scale, graded series of patterns or colours are the better choice (Fig. 2.6, Fig. 2.7). With graded series it is possible for the viewer to see relations in different areas. For example it is possible to decide that region "A" has a larger population than region "B", because region "A" is shaded in darker blue than region "B".

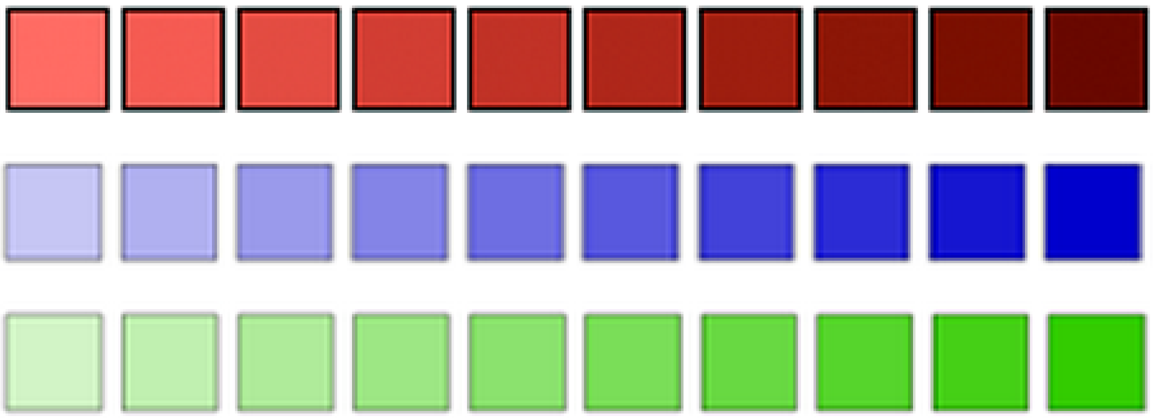

Figure 2.6: Example for graded colours. [Image extracted from open3, 2013]

If there are many classes an approach would be to use two series of colours or patterns. One for the classes above the average and one for the classes below the average.

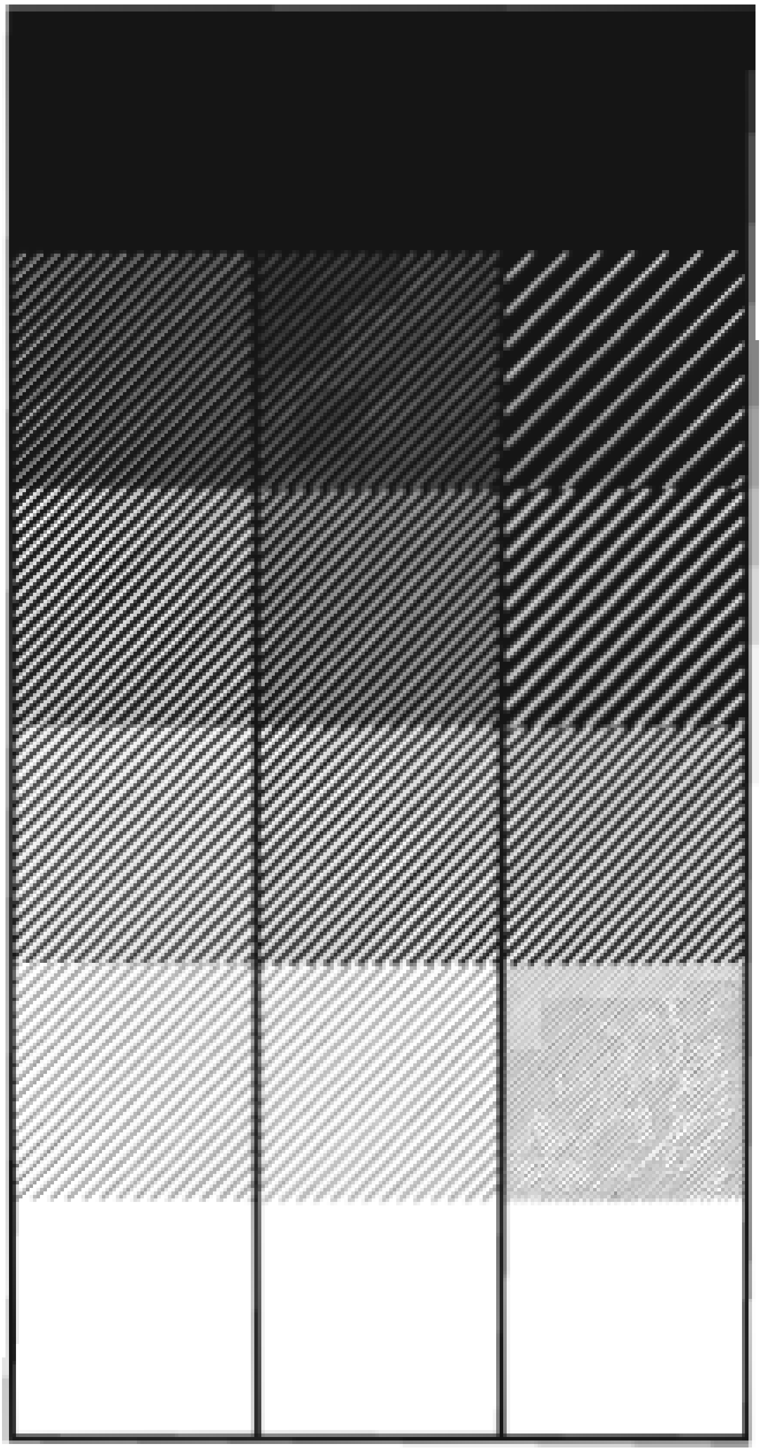

Figure 2.7: This picture shows an example for graded pattern series from John K. Wright. [Image extracted from Wright, 1938]

2.2.2 Number of Classes

The number of classes has to be determined for each Choropleth Map again and depends on the number of observations which should be possible to make with the Choropleth. Typically four to six classes are used because this number can be interpreted well. More than ten classes usually turn out to be hard to interpret for the viewer and on the other hand less than three or four classes have the drawback of loss of information and detail.

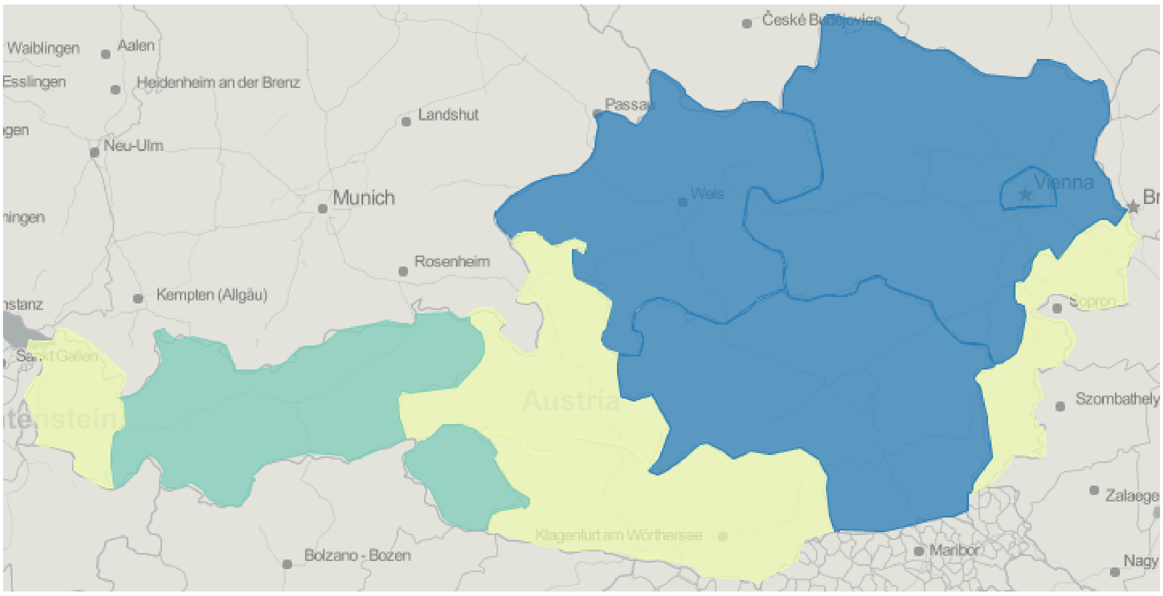

Figure 2.8: This picture shows a Choropleth Map with three classes. [Image extracted from geocommons, 2013]

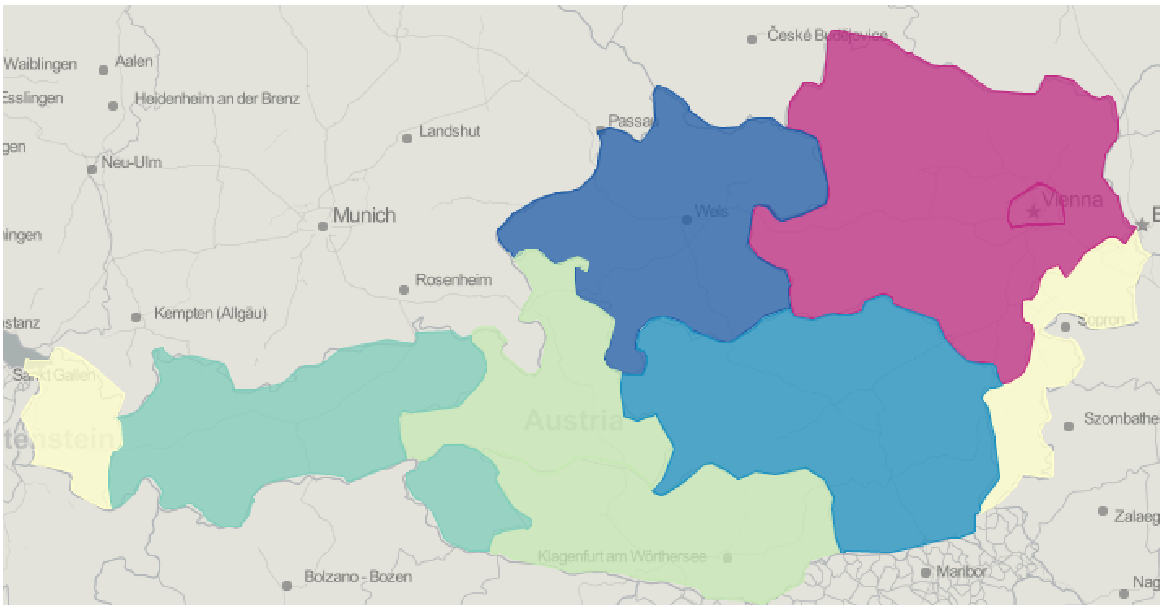

Figure 2.9: This picture shows a Choropleth Map with seven classes. [Image extracted from geocommons, 2013]

2.2.3 Classification Methods

Beside the choice of the colour and the number of classes the classification scheme does have a major impact on the visual impression of the Choropleth Map. In nominal or ordinal data, designers are generally given a set of classes. However with interval or ratio scale data, the data has to be grouped into classes. A focus in classification should be that the data:

- reveals spatial variation within areas and
- minimize the potential of misinterpretation of the map.

The most common classification methods which are typically available in choropleth tools are equal interval classes, nested means, quantiles, skewed distributions, and natural breaks.

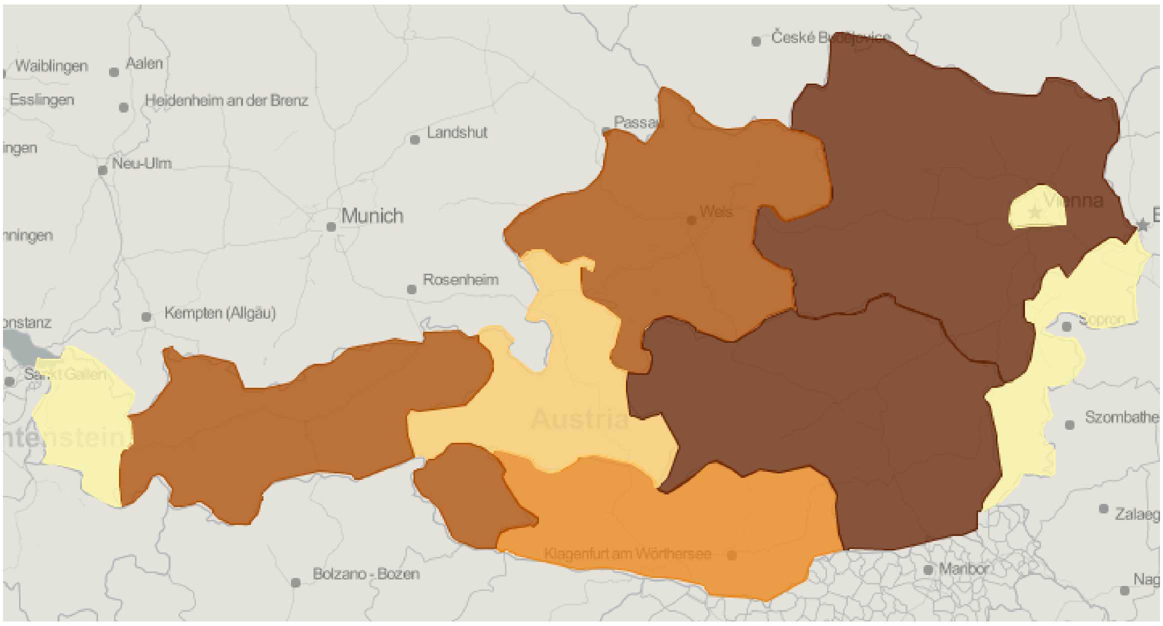

Figure 2.10: This picture shows a choropleth map categorized after the square kilometers per region with the equal inerval classification method. [Image extracted from geocommons, 2013]

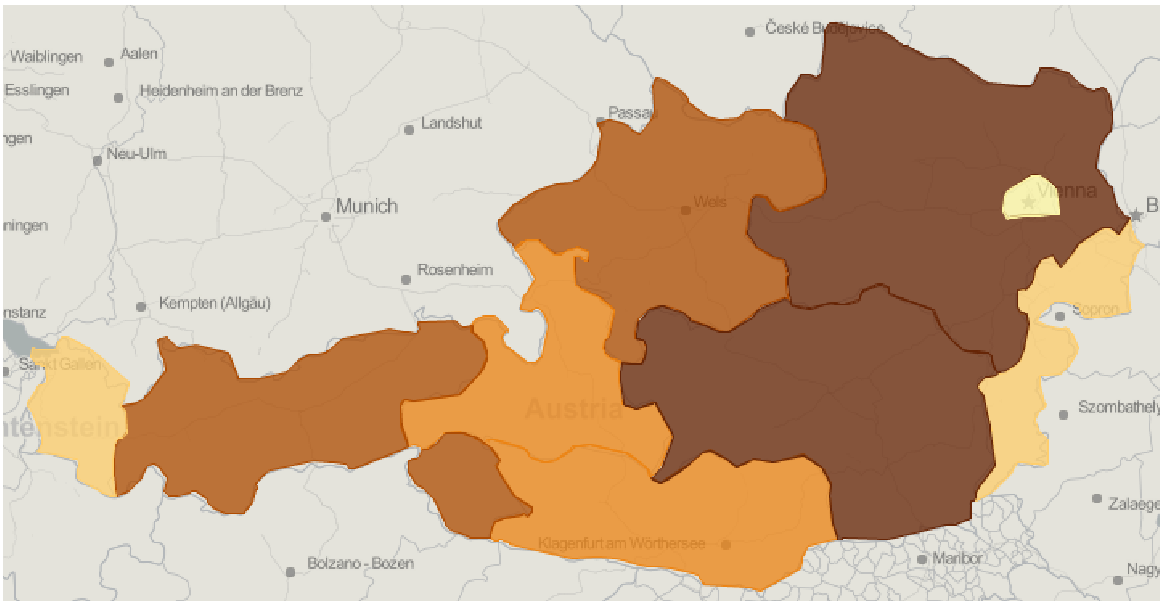

Figure 2.11: This picture shows a Choropleth Map categorized after the square kilometers per region with the max breaks classification method. [Image extracted from geocommons, 2013]

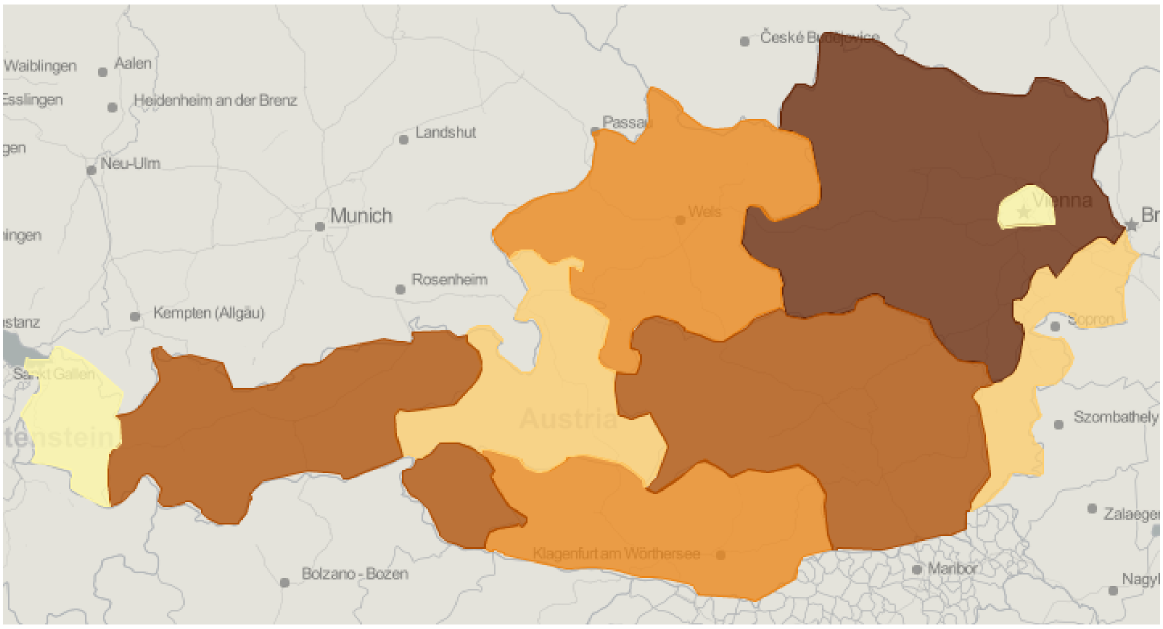

Figure 2.12: This picture shows a choropleth map categorized after the square kilometers per region with the quantile classification method. [Image extracted from geocommons, 2013]

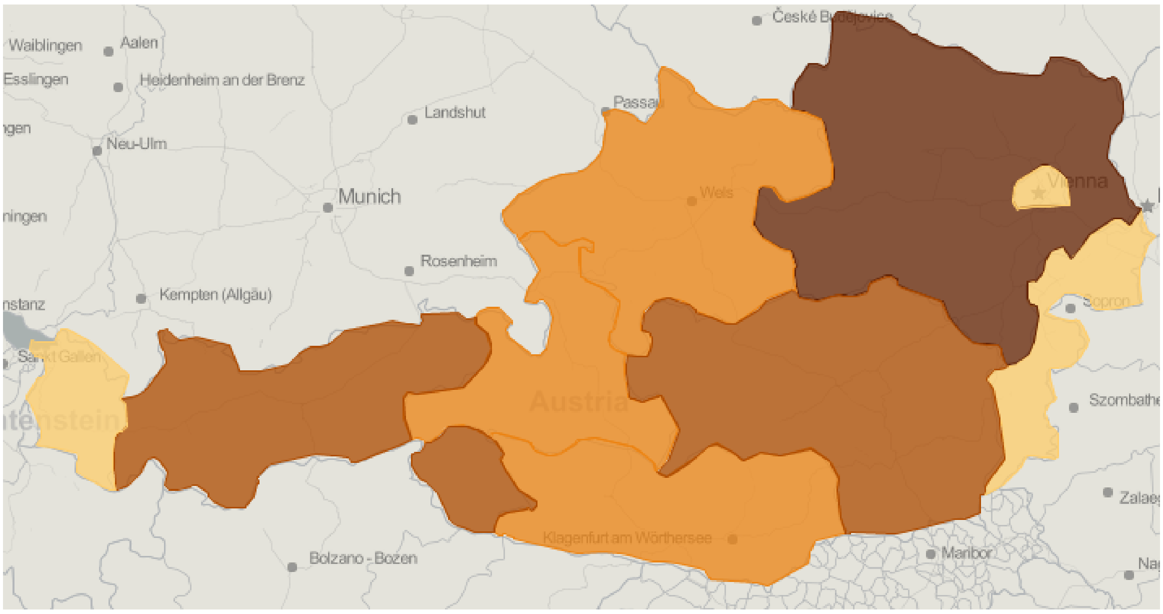

Figure 2.13: This picture shows a choropleth map categorized after the square kilometers per region with the standard deviation classification method. [Image extracted from geocommons, 2013]

2.3 Change Blindness

Change Blindness describes the inability to detect change in an animated map. The map changes in every frame and people tend to have problems to find those changes in adjacent frames. The phenomenon of "Change Blindness Blindness" means that most viewers think they are not affected by "Change Blindness". Viewers think they see all changes but in reality they miss most of the changes. This leads to many problems for the generation of animated maps. The duration of the transition time between two images is crucial to the understanding of the animated data. There exists no optimal time and the problem cannot be solved in general for every map. A long transition time can hide small changes in regions and a too short time can hide changes at all. Highlighting the changing regions can help to identify the important regions but if there are too many changes like in Fig. 2.14 it is very hard to highlight all changes without overwhelming the viewer. [Carolyn Fish, 2011]

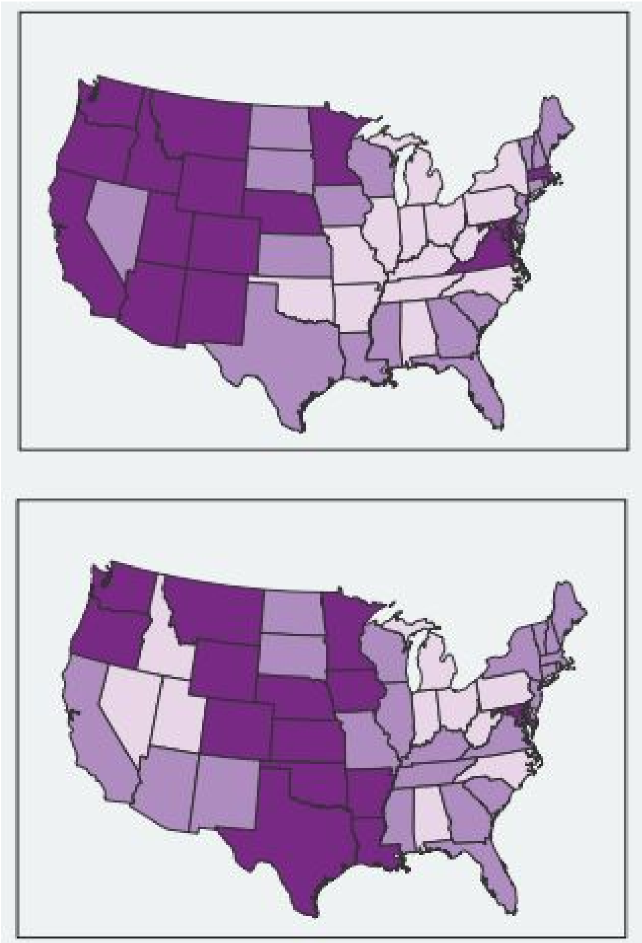

Figure 2.14: Two frames from an animated Choropleth Map [Fish, 2009]

2.3.1 Datamaps.eu

Datamaps.eu is an online tool which can create Choropleth Maps. Datamaps is a product from open3, an organization to promote the usage and release of open data in Austria. The language is german and only a translation to english via Google Translate is possible. The provided shapes to create maps are limited and no own shapefiles can be used. Austria has many shapes from federal states to commune. Only the colour is changeable to create customized maps. There exist a few colour palettes to choose from and it is possible to create own color schemes by entering their hexaeciaml values. The output can be saved as PNG or SVG and the maps can be published under the creative commons 3.0 license. The data values can be inserted manually via a list as JSON or in the csv format. The generated map is free to use. Output from Datamaps.eu looks like Fig. 2.15

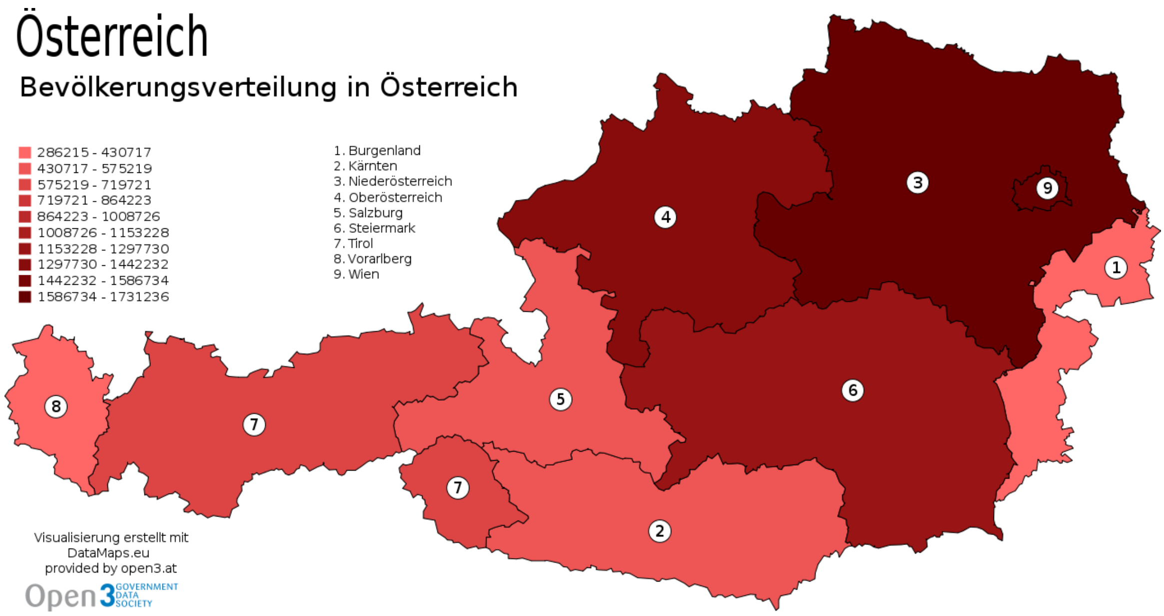

Figure 2.15: This picture was generated with the online tool from [open3, 2013]

2.3.2 www.imapbuilder.com

Three different versions of this tool exist. Two versions run on a local PC, the third is accessible over the web browser. Only the "Local Flash Version" can export jgp images. No other file formats are supported. A huge library for shapes exists in the program and own shapefiles can be used. The tool is complicated to use and adds a watermark in the trial version. The exported image has no legend and only a very small resolution. The output from imapbuilder.com looks like Fig. 2.16

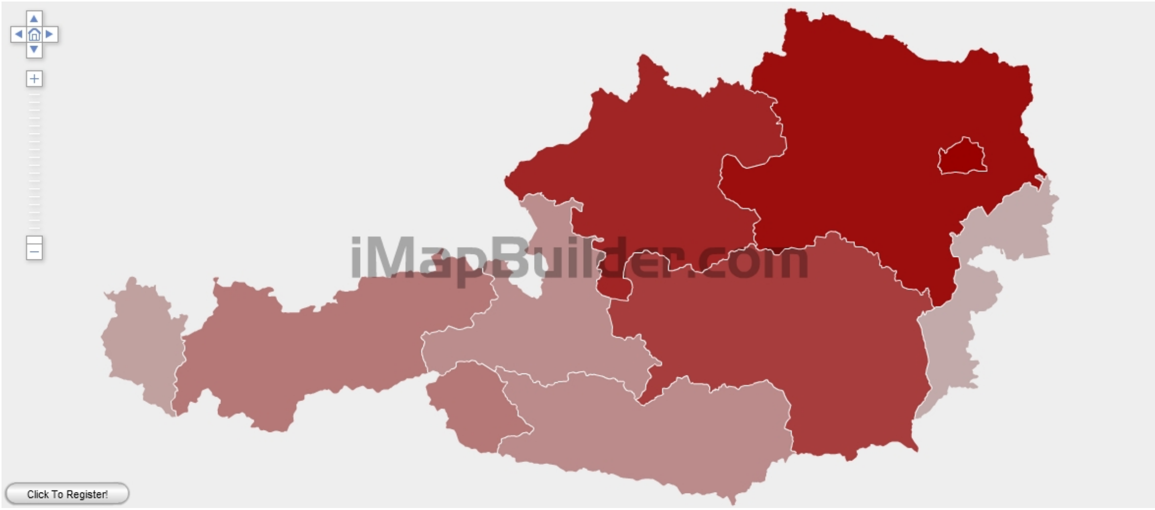

Figure 2.16: This picture was generated with the standalone flash tool from [imapbuilder, 2013]

2.3.3 geocommons.com

Geocommons.com is a powerful online tool. The datasets and created maps can be shared with other users of the website. To upload and save your own data it is necessary to create an account. Own shapefiles can be used and a huge database of shapes exists. It is possible to reuse existing maps from other users. One may also investigate the data with statistical tools and filters and to create new maps generated from those filters. The tool is free to use but there is a usage quota per day if this quota is exceeded a custom solution with geocommons must be found. With the enterprise version it is possible to manage private or sensitive data. Various tools to track and analyse the usage of your data exist. The created maps can be exported as kml file which can be imported in Google Earth and the created data can be exported as csv were many properties of the regions are stored. It is also possible to export a png file but the better way would be to take a screenshot because the exported image file is inconsistent with the displayed data. Furthermore the resolution is very small. The exported images look like this picture: Fig. 2.17 and the screenshot looks like this Fig. 2.18

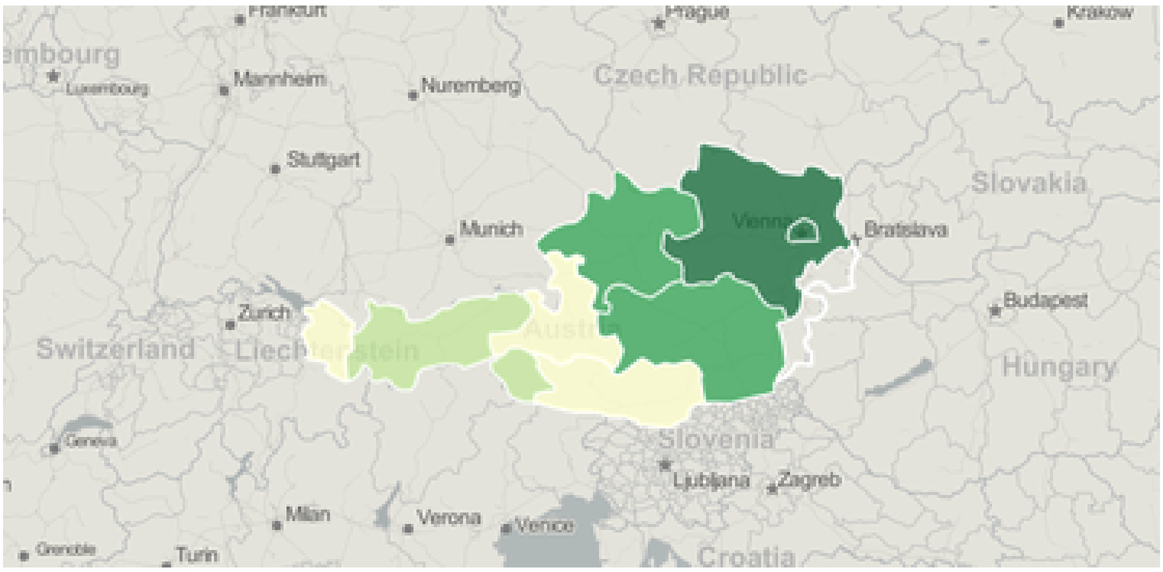

Figure 2.17: A exported image from [geocommons, 2013]

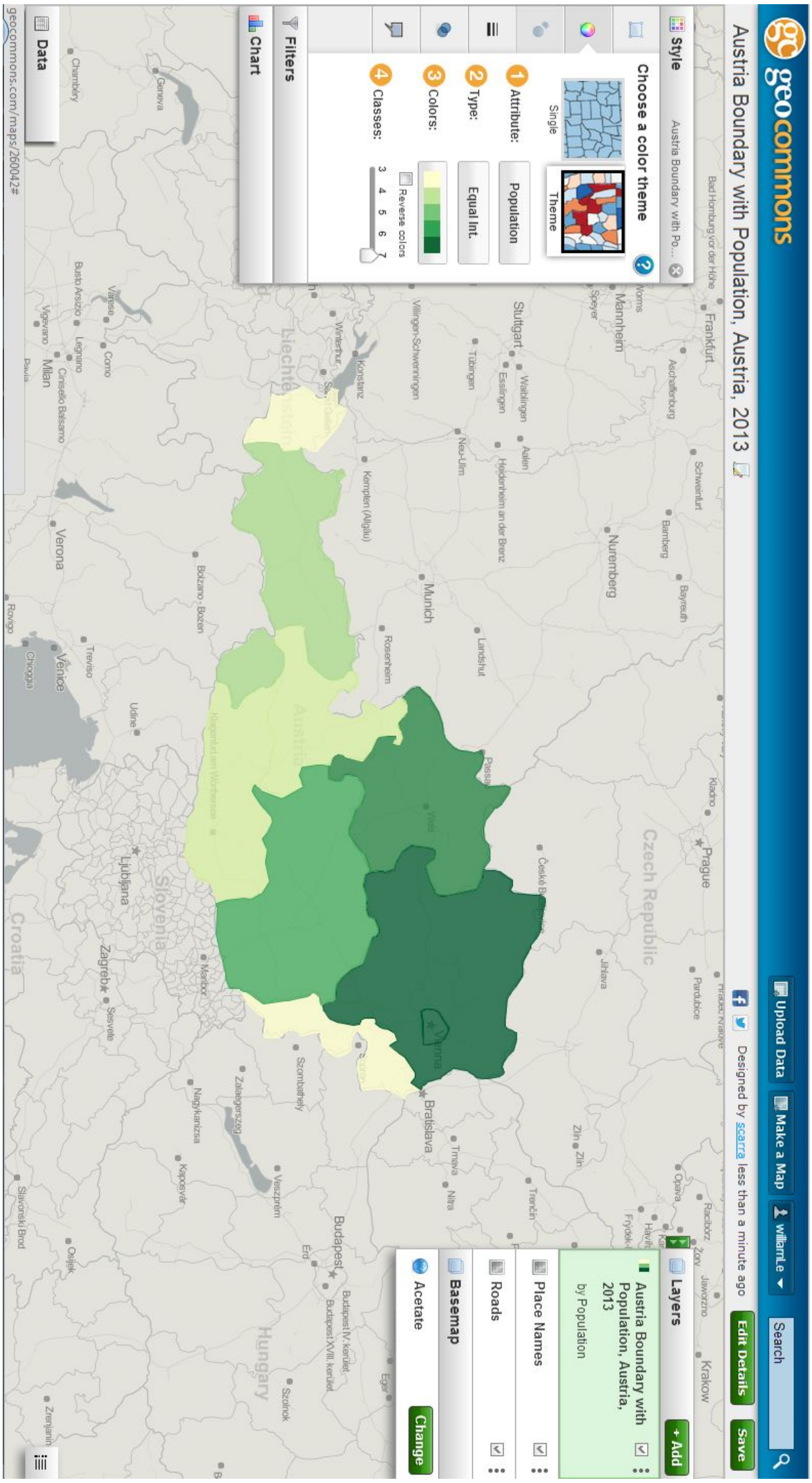

Figure 2.18: A screenshot from [geocommons, 2013]

2.3.4 Liquid Diagrams

Liquid Diagrams is a project of the IICM of Graz, University of Technology to provide various visualization techniques. The program des run locally and is implemented in Adobe Air. Data can be provided via xls, ods or csv files but there is no interface to manually insert data into the tool. The regions are specified via ISO code [Ladenhauf, 2013, page 85]. It is possible to show non-numerical data in the heat map visualization. Regions with the same data values are shown in the same colours. Of all the tested programs, this was the only one which is able to produce 3D maps as shown in Fig. 2.19. One property - in this case the ruling party - is mapped to the colour and the second property - the number of inhabitants - is mapped to the height of the region. A conventional Choropleth Map is shown in Fig. 2.19 where the saturation of the colour is mapped to the number of inhabitants. The generated map can be exported as PNG or SVG image. The software is free to use without fee. The only downside of the program is the long render time when generating a map.

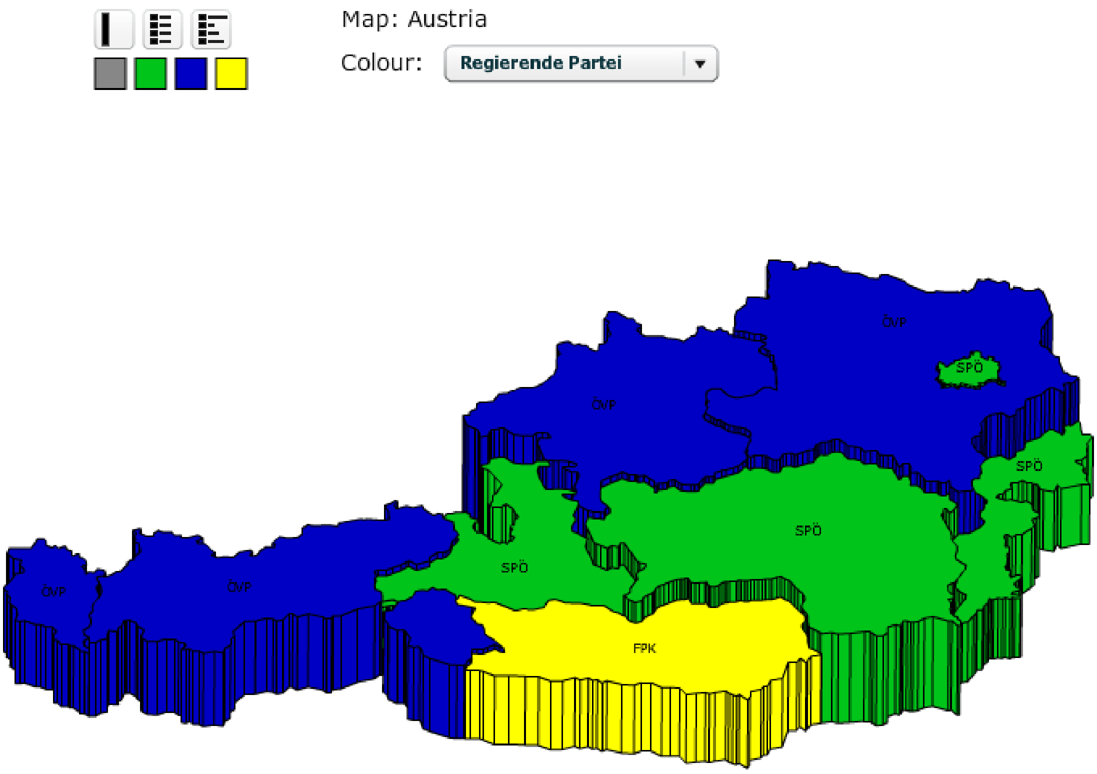

Figure 2.19: A 3D image created with Liquid Diagrams

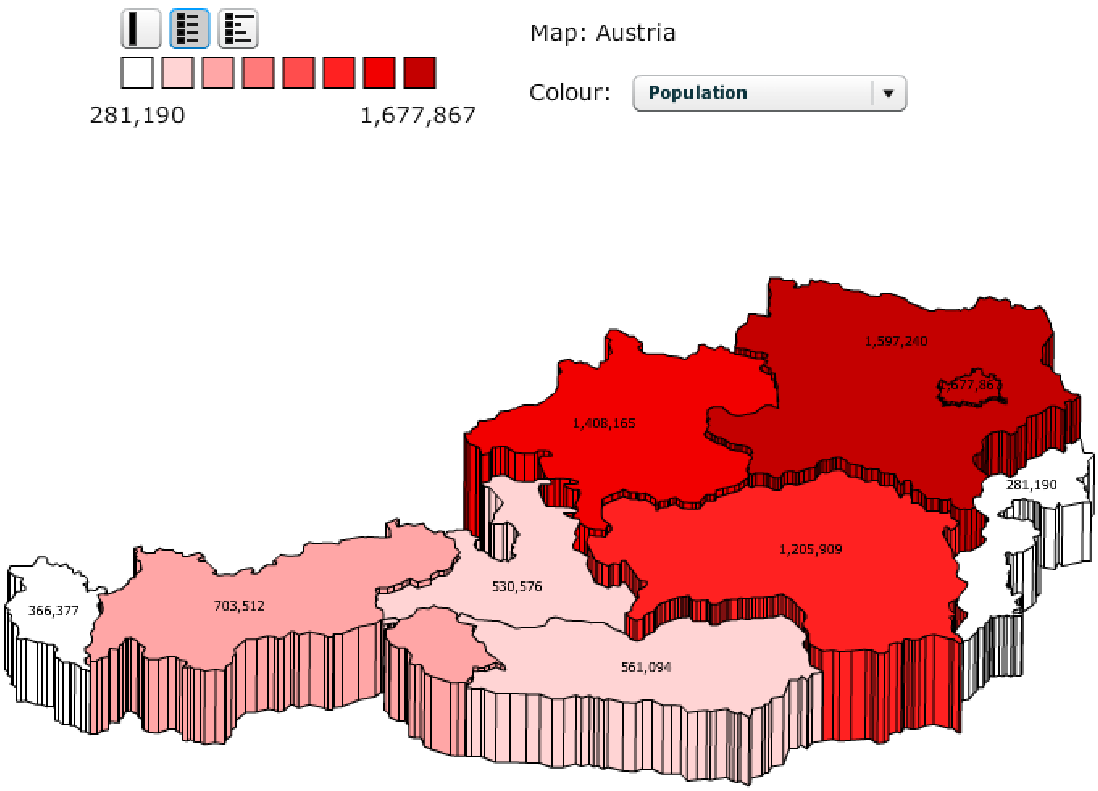

Figure 2.20: A image created with Liquid Diagrams

Chapter 3

Slippy Maps

3.1 Introduction

The name Slippy Maps describes modern web maps, which allow the user to zoom and pan around. These kind of maps are named Slippy Maps, because the map slips when the user drags the mouse. The term Slippy Map itself was introduced by OpenStreetMap, which was launched in July 2004 and originally only refered to the map display on www.openstreetmap.org (Fig. 3.1). Slippy Maps are technically a web interface which displays rendered map data. The previous shown example does display the OpenStreetMap data. The two propably most known und most used Slippy Maps on the internet will be explained more thoroughly in this paper. These are OpenStreetMap and Google Maps.

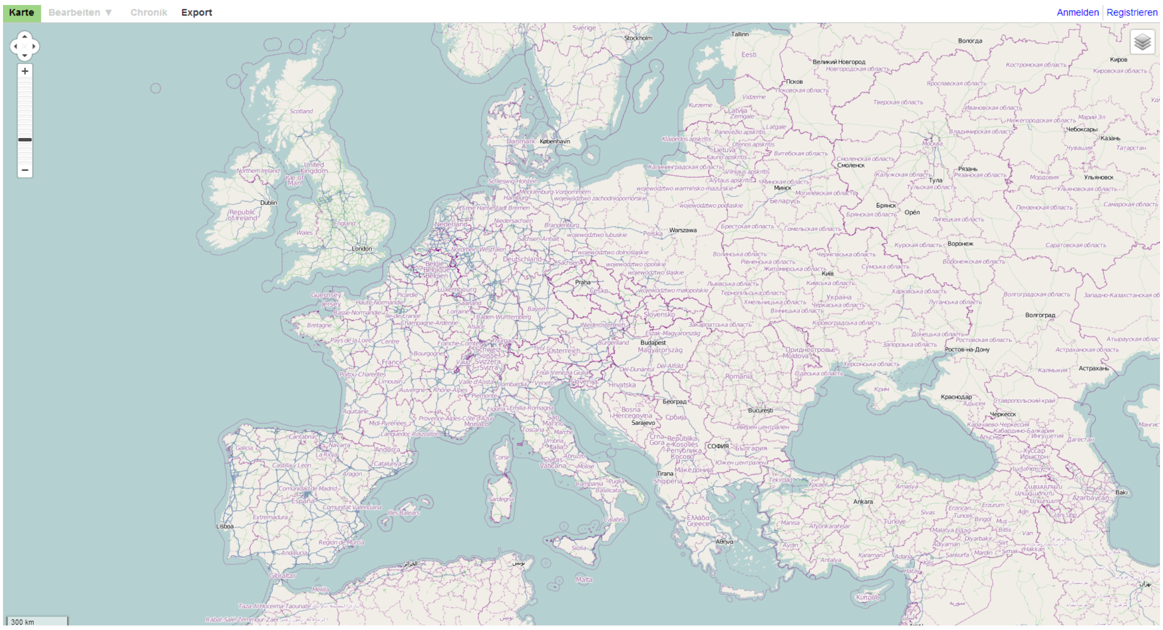

Figure 3.1: This figure shows the web interface of www.openstreetmap.org [*OpenStreetMap*].

3.2 The Slippy Map

A Slippy Map consists of several raster images, the so called tiles, which form the map the user sees when put togehter (Fig. 3.2). The webbrowser uses Javascript and Ajax to dynamically load the tiles from a webserver. Due to the fact that rendering map data to form tiles is a resource intensive process, the tiles need to be prerenderd and cached on a server first. This makes navigating through the map look fluently to the user. To keep tiles accurate, the server needs to rerender them within several days.

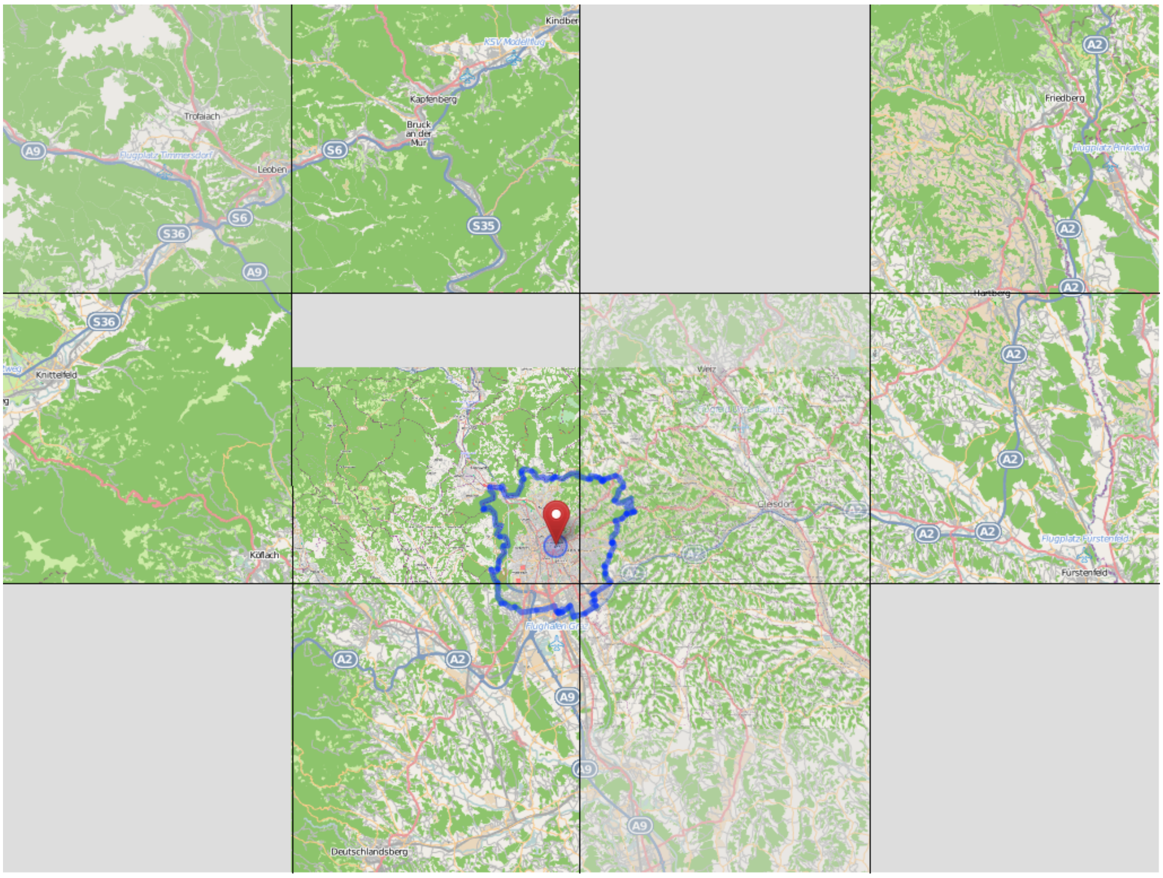

Figure 3.2: The process of loading tiles, which can be overlayed with lines and placemarks. www.openstreetmap.org [*OpenStreetMap*]

OpenStreetMap uses a rendering software called Mapnik to generate tiles. Mapnik is an open source tool, available for Mac OS X and Windows. It generates a variety of image formats out of map data, like PNG, JPEG, SVG, and PDF among others. In the case of OpenStreetMap, the tiles are raster images at the size of 256*256 pixel (*Mapnik*).

3.3 Google Maps

Google Maps is an online map service, that allows to view street maps and provides a navigation system. Beside that it also enables the user to create an own map. Therefore a web interface and an application programming interface stand at the proposal of the user. In both cases, using Google Maps require a Google account to be used.
This subsection of the paper will now give an introduction to the web interface of Google Maps. The tools allow the user to name the newly created map and give a description, which may be important if the user decides to publish the map (Fig. 3.3).

As shown in Fig. 3.4 a toolbox provides the items placemarks, line and shape to be placed as indicator on the map. These indicators are not added to the map itself, they just overlay it.

Fig. 3.5 is an example for an user-created map on Google Maps. The background is a satellite image of Graz, where paths, areas and placemarks have been added as part of the map. User-created maps may be published either on the Google Search Engine or as a hyperlink.

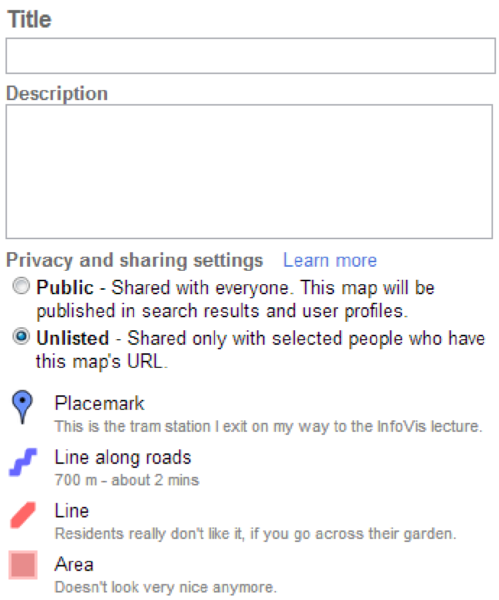

Figure 3.3: Main menu of the editing section on the Google Maps web interface. It allows to make certain settings to user-created maps like naming and describing the map. It also gives an overview on all items which the user has placed on the map. Google [*Google Maps*]

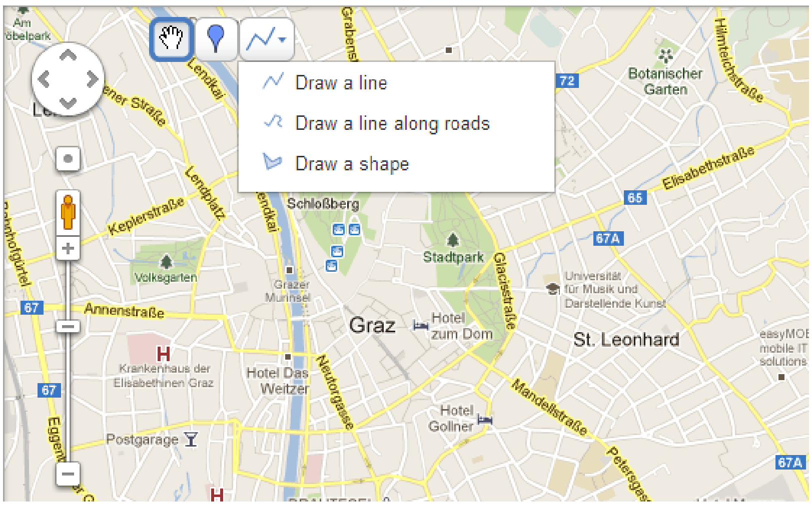

Figure 3.4: This toolbox appears in the upper left corner of Google Maps if an own map is created or edited. It allows the user to place certain markings like placemarks, lines and areas on the map. Google [*Google Maps*]

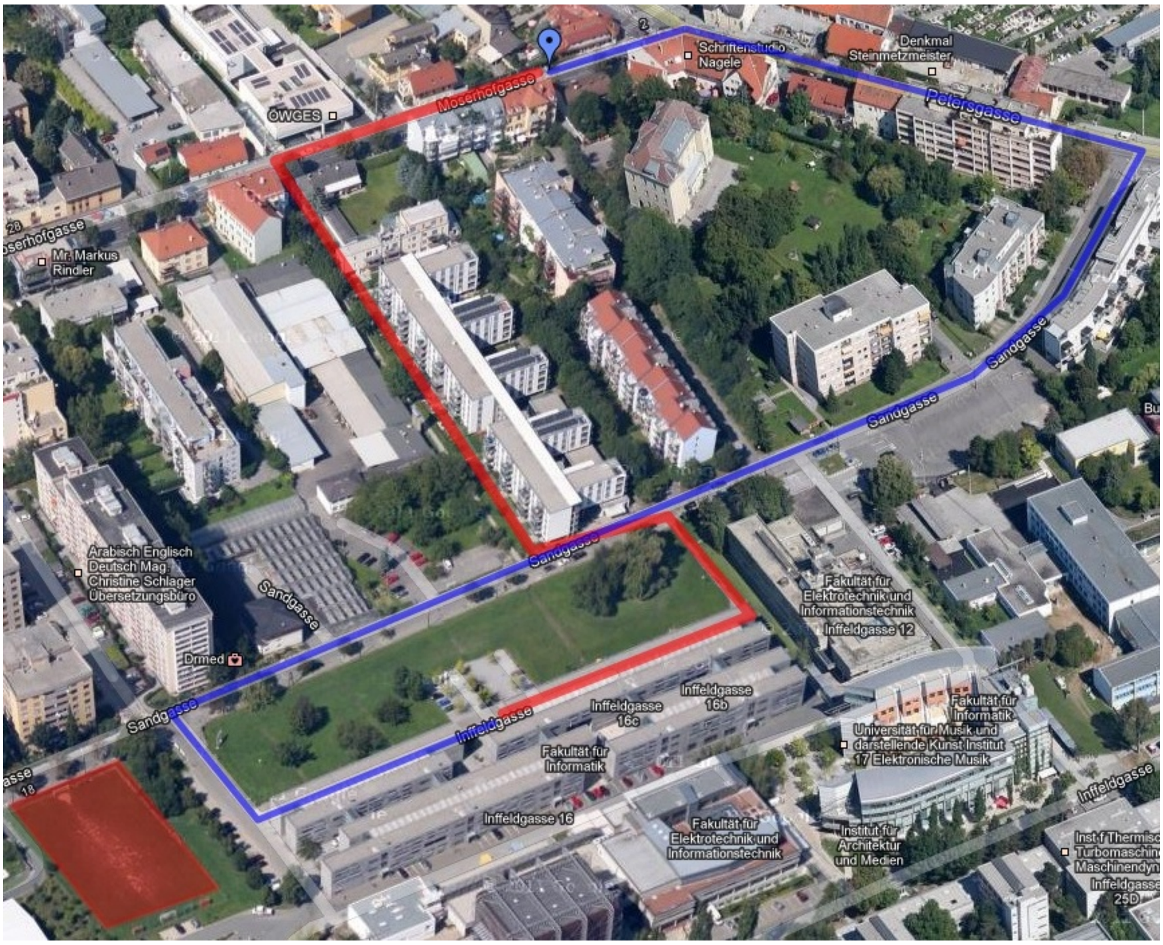

Figure 3.5: Example for an user-created map on Google Maps, which contains lines in blue and red, an area in red and a placemark. Google [*Google Maps*]

3.4 OpenStreetMap

OpenStreetMap (OSM) is a project to create free-to-use editable maps. The website www.openstreetmap.org allows users to download, add and edit map information, which can either be done on the OSM website or by using a desktop program which modifies the downloaded files. The recommended desktop tool to do so is JOSM, the Java OpenSteetMap Editor (Fig. 3.6).

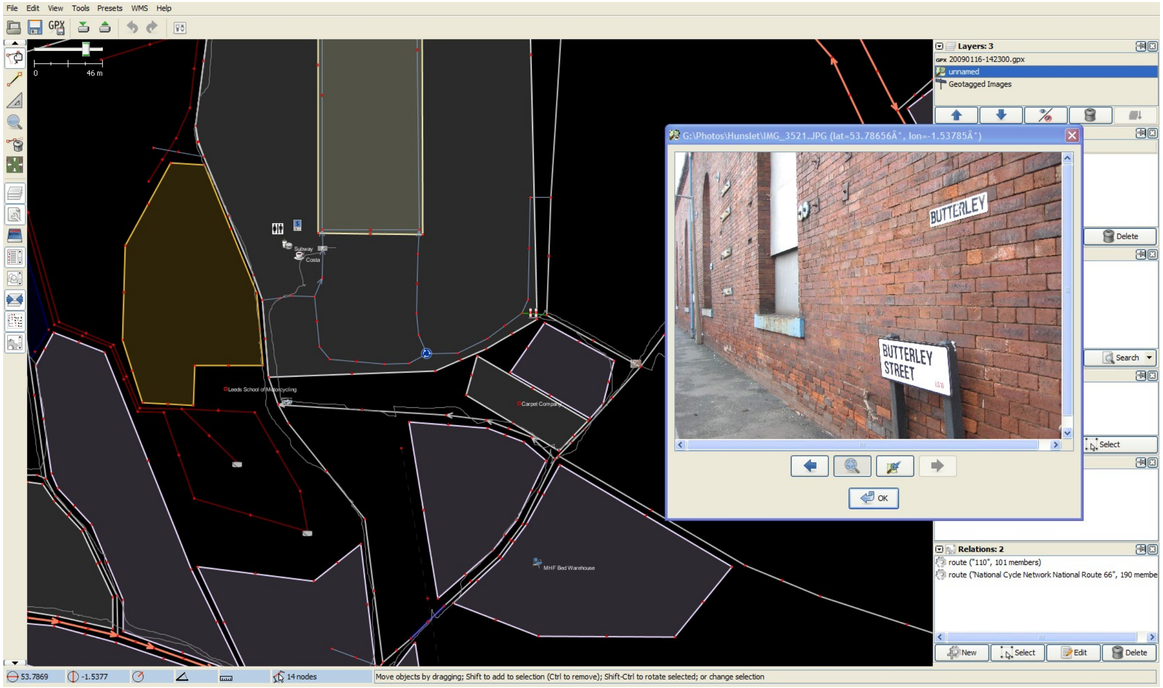

Figure 3.6: Screenshot of the Java OpenSteetMap Editor (JOSM), showing the process of embedding pictures to the map. www.openstreetmap.org [*JOSM*] www.openstreetmap.org [*JOSM Editor*]

OpenStreetMap also provides an API called OpenLayers, which allows the user to create own maps instead of modifying map data like explained above. Simmilar to Google Maps, users may place lines, areas and placemarks on it, which then overlay the map. Compared with Google Maps, OpenSteetMap does not provide a web interface to create such maps. Instead of that, users would have to use the API in order to do so. However some tools exist on the internet, which provide a web interface, but again these tools work based on the just mentioned API. Below an example for such a web interface will briefly be introduced and some examples for user-created OpenSteetMaps will be given.

3.4.1 OSM SlippyMap Generator

The OSM SlippyMap Generator is a tool provided by the website osmtools.de. Additionally to the features shown in Fig. 3.7, it allows users to put lines, shapes and placemarks on the map to mark certain areas or locations. Compared to Google Maps, the handling of this tool isn't quite easy (e.g. colours have to be entered as hexadecimal code and can't be choosen out of a sample board).

Examples for user-created OSM maps are shown in the Figures 3.8 and 3.9.

3.5 Slippy Maps as Choropleth Maps

Both Google Maps and OpenStreetMap provide APIs which allow users to create placemarks, lines and shapes in arbitrary colours. For using a Slippy Map as Choropleth Map the user has to provide the coordinates of the borders and the colours according to the values of the regions. A shape could for example be used to highlight a specific region, like demonstrated in Fig. 3.10.

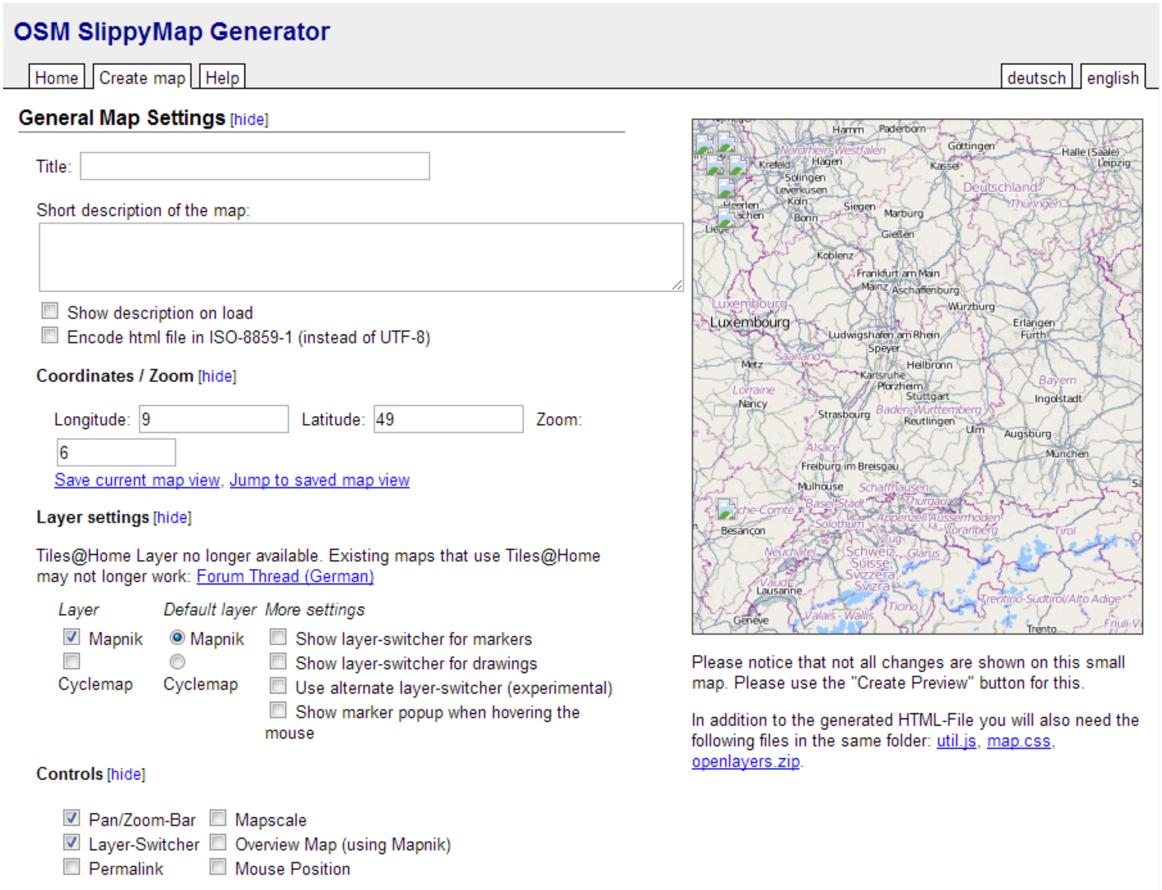

Figure 3.7: Screenshot of the OSM SlippyMap Generator on osmtools.de, showing the description and title fields, a preview of the map and selectable options regarding user-controls and layers. www.osmtools.de [*OSM Tools*]

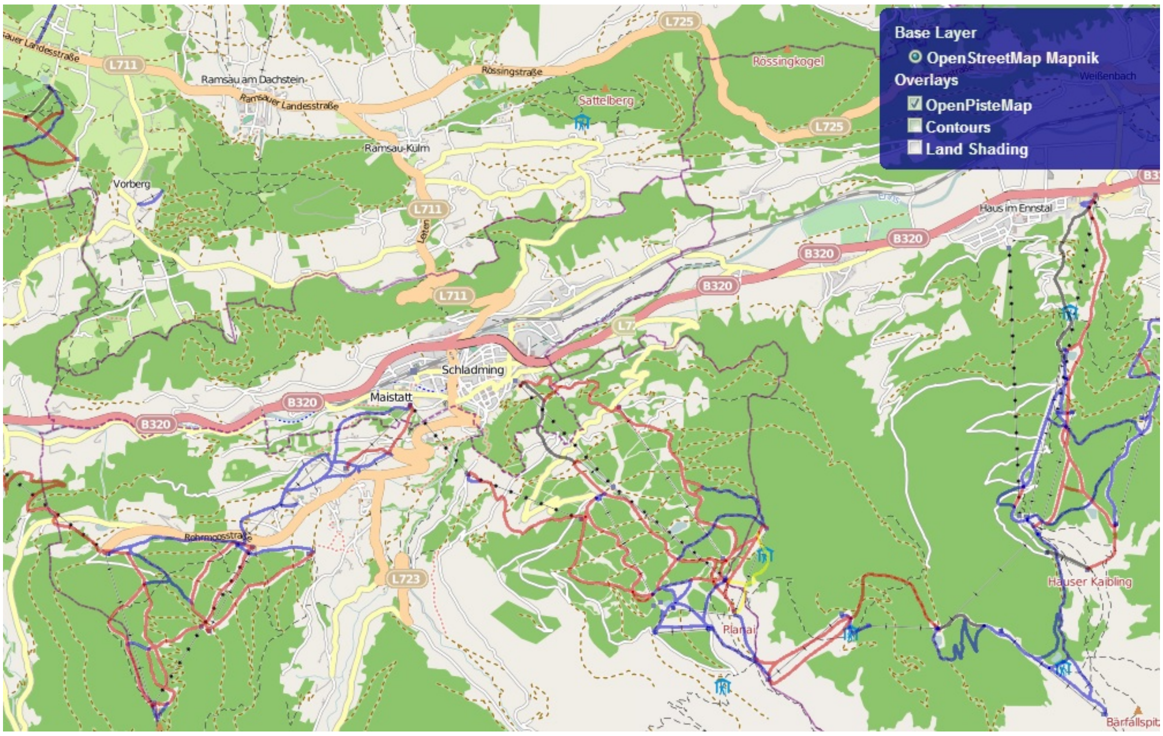

Figure 3.8: Screenshot of OpenPisteMap. A user-created map, containing information on ski slopes. www.openpistemap.org [*OpenPisteMap*]

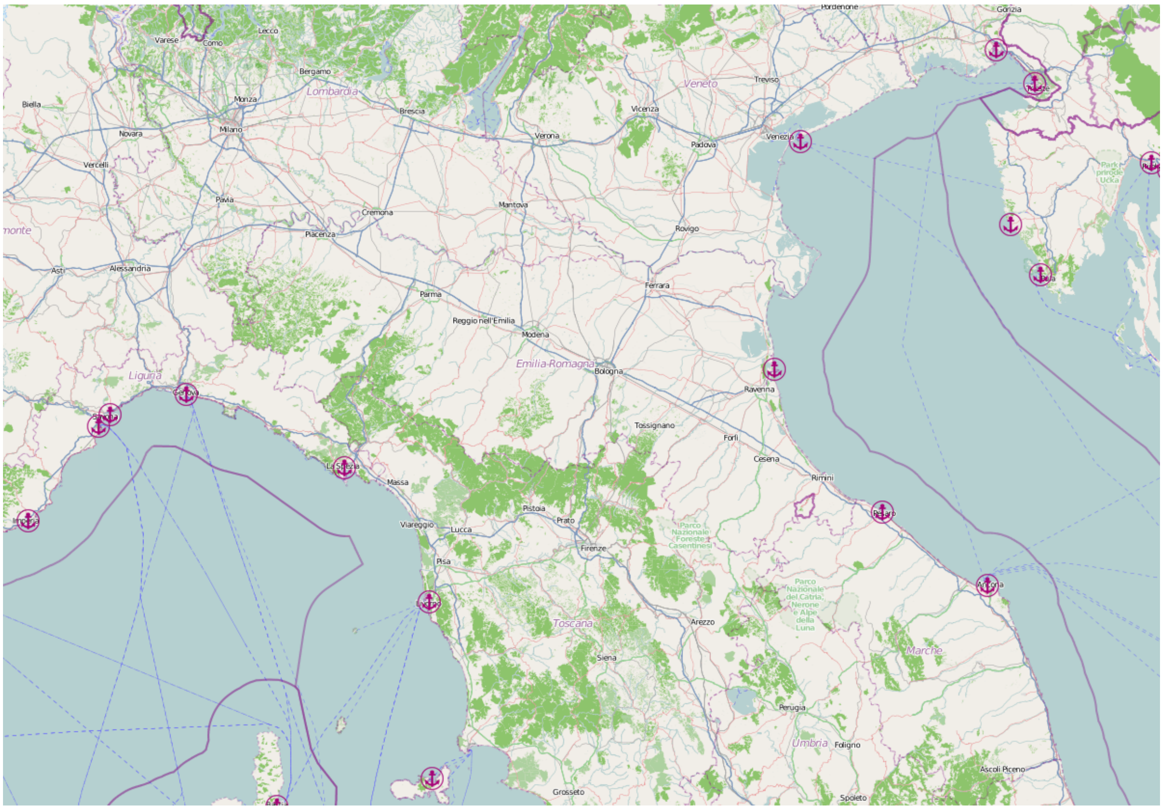

Figure 3.9: Screenshot of OpenPisteMap. A user-created map, containing ship routes and harbours. www.openseamap.org [*OpenSeaMap*]

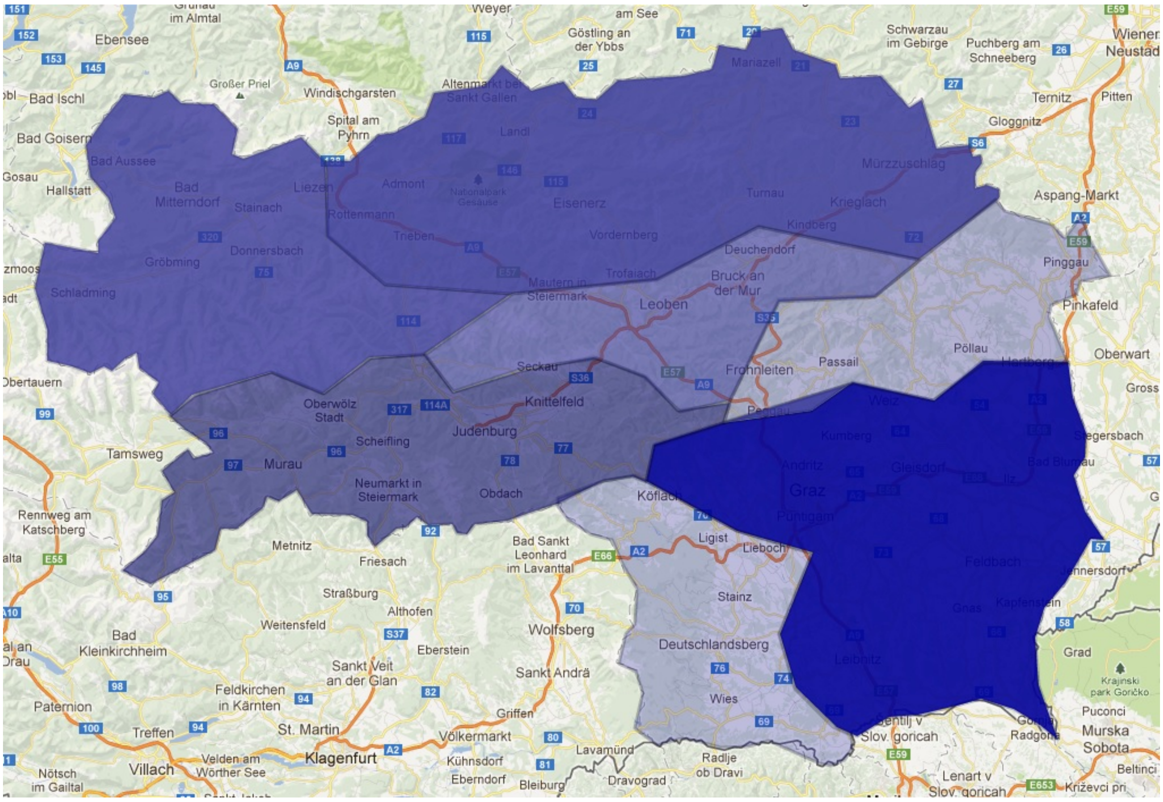

Figure 3.10: Example for a Google Map, used as Choropleth Map, showing value related colours in randomly choosen regions. Google [*Google Maps*]

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