MAP SYMBOL BREWER – A NEW APPROACH FOR A CARTOGRAPHIC MAP SYMBOL GENERATOR

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ABSTRACT

This project allows cartographers and non-specialists to generate map symbols for screen maps with a main focus on internet maps. Research was done in the field of representation of quantitative absolute values to find a more flexible and easier way, than current approaches, to generate map symbols (e.g. diagrams). After a comparison of the current literature a ranking of graphical symbol properties was established. Furthermore, with several graphic primitives, some arrangement principles and data directions almost all point-related map symbol situations were derived, ranging from proportional scaled map symbols over combined map symbols to diagrams.
A prototype called "Map Symbol Brewer" was developed to demonstrate our assumptions. The client is written in SVG and ECMAScript and runs in every web browser and operating system supported by the Adobe SVG viewer. XML-based thematic data can be represented with our tool. With few interactions users can create their own map symbols.

1 RESEARCH FIELD

1.1 Map symbols

In many thematic maps the map topic is visualized by using map symbols. These topics consist of qualitative, ordered or quantitative data. If the values are absolute, the three different kinds of data are related to a position in the map. For these data values point-related symbols will be used. These point-related map symbols can be divided in

- pictorial symbols,
- symbolic symbols,
- geometrical symbols,
- character and numeral symbols and
- diagrams (figure 1) [Hake et al. 2002].

Figure 1: Point-related map symbols

Usually occurences and positions of objects are *qualitative data* and will be visualized with the first four groups. *Graduated data* needs to be classified or grouped and can also be represented with the first four groups. The third group, *quantitative data* can be shown directly with all five groups of point-related map symbols. For example geometrical symbols can be scaled proportionally to the data (figure 2). In this work we deal with quantitative data, especially absolute values. To measure and estimate the value of such a map symbol the user needs to know whether it is necessary to measure the height, width or area of the symbol. Figure 3 demonstrates the problem of estimating the value from pictorial, symbolic or character symbols in printed maps. In interactive internet maps the value can be shown per interaction, e.g. per mouse event. But in static internet maps the problem still exists. So, only geometrical symbols and diagrams are useful for all kinds of map.

Figure 2: Proportional scaled geometrical map symbol

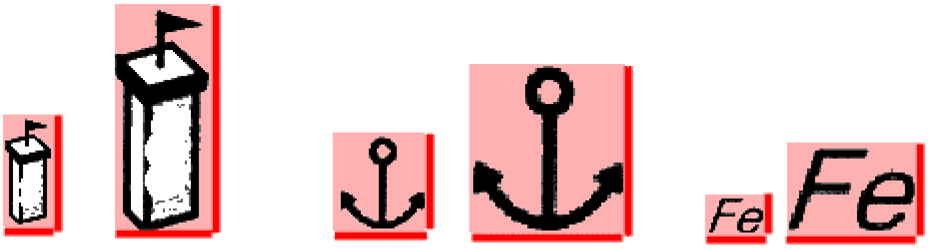

Figure 3: The value of the pictorial, symbolic and character map symbols can be estimated as width, height or area.

1.2 Current approaches for map symbol generation

Map symbols can be created *by hand*, *interactively* (half-automatically) or *automatically*.
Generation by hand is very time- and work-consuming, but allows adaptation of the symbol to the needs of the user. For example the map maker may want to use an anchor to express the topic "number of ships per harbor" better.
A second possibility is automatic generation. This approach is very fast, since there is no interaction necessary with the user. But this approach will fail when it comes to the adaptation of automatic input data analysis and symbolization according to the needs of the users.
The usual way is the interactive creation of map symbols. This method allows a faster generation of a map symbol with a high adaptation level to the need of the user. Programs like Geographical Information Systems (e.g. ESRI ArcGIS [Esri 2005]), Plugins for drawing programs (e.g. THM plugins for Adobe Illustrator CS [Hutzler 2005]) or mapping programs (e.g. Golden Software MapViewer [MapViewer 2005] or GraS Themak [Themak 2005]) work in this way. But the generation of map symbols with these programs is often differently from program version to program version. A further disadvantage is the use of symbol libraries in such programs. For a small change in the appearance of the symbol a new symbol library needs to be created (figure 4).

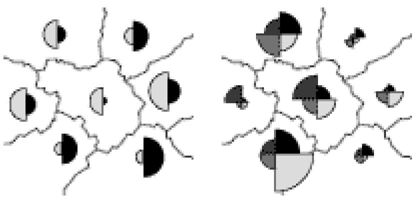

Figure 4: A small change in the diagram appearance – four instead of two diagram wings

Furthermore, some symbol libraries are easier to create than others, and so there is a tendency for simplier map symbols to be used. Mersey (1996) examined eight atlases concering the use of map symbols. 36 percent of the maps used proportional map symbols. More than 61 percent of these proportional symbols were scaled circles, squares and bars [Mersey 1996]. A second study came to the conclusion, that from 13 examined mapping programs and GIS only nine could create proportional map symbols and only six diagrams such as pie charts [Mersey 1996].

2 GOAL

Therefore the goal of this project is to develop a theory to generate complex, user-defined map symbols as easy and flexible as possible. A tool to apply this theory has been developed to generate map symbols, that can be used in interactive map applications.

3 THEORY BEHIND THE MAP SYMBOL BREWER

The problem to create map symbols as fast and easy as possible can be divided into two parts:

First, the map symbol has to be designed. Secondly, this symbol has to be applied in the map and the appearance changed based on the given thematic data. Current literature can provide ideas and mechanisms to solve the problem in the following two steps.
With the help of the symbol classifications by Arnberger [Arnberger 1977], Imhof [Imhof 1972], Wilkinson [Wilkinson 1999], Schroeder [Schroeder 1985], to name a few, a nearly complete list of frequently used symbols could be created. These symbols could be examined concerning their properties, e.g. their appearance and data representation (statement).

3.1 Map symbol properties

General map symbol properties are simplicity and a good perceptibility [Focus 2004]. Furthermore, it should be compact and explicit.
The map symbols have special graphical properties, which describe its appearance. Graphical properties are described by Bertin [Bertin 1974], MacEachren [MacEachren 1994] and Neudeck [Neudeck 2001] (figure 5):

- the position
- the size
- the shape
- the texture
- the orientation
- the hue
- the value
- the saturation
- the transparency
- the focus

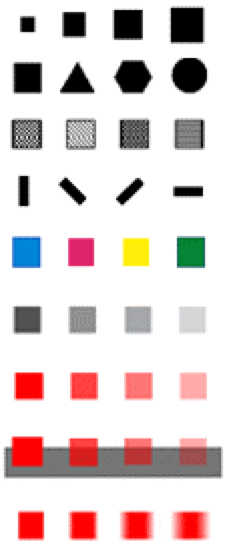

Figure 5: Graphical properties of a map symbol

Further properties like arrangement, perspective height, animation and blinking were discussed by several authors, but emerged as combination or parts of the named properties. For example, the strength of the 3D effect (named by Slocum [Slocum 2005] as perspective height) is only another occurence of the size.

3.2 Analysis of the map symbol properties

The change of the graphical property "size" is the best way to visualize absolute quantitative data. The size can be changed length, area and volume proportional, or with a floating scale according to the data. There exist three possibilities to show the data with the graphical property "size":
First, a *simple geometrical symbol* is used for one data value per coordinate point in the map. The symbols are scaled according to the data (figure 2).
Second, *repeated symbols* are used. This method represents one data value per coordinate point in the map by repetition of one symbol of uniform size and character, arranged in a grid (figure 6).
Third, a *diagram* is used for more than one data value per coordinate point on the map. Each diagram part is scaled according to the data, e.g. the bars of a bar chart (figure 7).

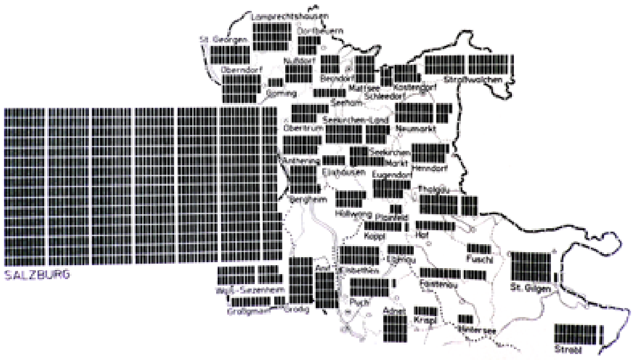

Figure 6: Repeated symbols (example from [Arnberger 1977])

Figure 7: The size of the diagram parts will be changed according to the data

The other graphical properties like hue and value can be combined with the size to increase the force of expression. The shape can be combined with the size, but decreases the measurability of the symbol.
The texture can only be used in combination with the size, if big symbols are used [Bertin 1974]. The texture can also cause graphical disturbances on the screen [Neudeck 2005].
The orientation in combination with the size prevents the comparability of the map symbols. Furthermore, the range of changes are reduced, because the rotation of a map symbol allows only a range of zero to 360 degrees. For symmetric symbols the range is even more reduced.
The hue has a high graphical weight and expresses qualities. Therefore, a combination of the size with the hue would reduce the force of expression of quantitative data (figure 8). But the combination of both graphical properties can be used to express differences, e.g. of diagram parts and emphasize the togetherness of the equal parts of different diagrams in the map.

Figure 8: A combination of hue and size decreases the force of expression of the map symbol

The value and the saturation can be easily combined with the size and therefore increase the force of expression (figure 9). Transparency and focus can only be combined with the size, if a hue, value and/or saturation is given. Therefore, these graphical properties should only be used, if a third property is necessary.

Figure 9: A combination of value and size increases the force of expression of the map symbol

3.3 Construction of map symbols

More than 50 map symbols were analyzed to find similarities and differences in the structure of the symbols. Three-dimensional symbols were excluded from the research because of their poor accuracy of estimation or measuring of values compared to two-dimensional symbols. As result of the analysis three conclusions could be made:

1. The analyzed map symbols consist of graphical primitives (basic shapes).
2. The graphical primitives can be arranged with few arrangement principles.
3. The size of the graphical primitives can be changed according to the data. The change follows a certain direction.

3.3.1 Simple map symbols

Graphical primitives

Simple map symbols have 3 graphical primitives: an ellipse, a symmetric polygon and a pie sector (figure 10).

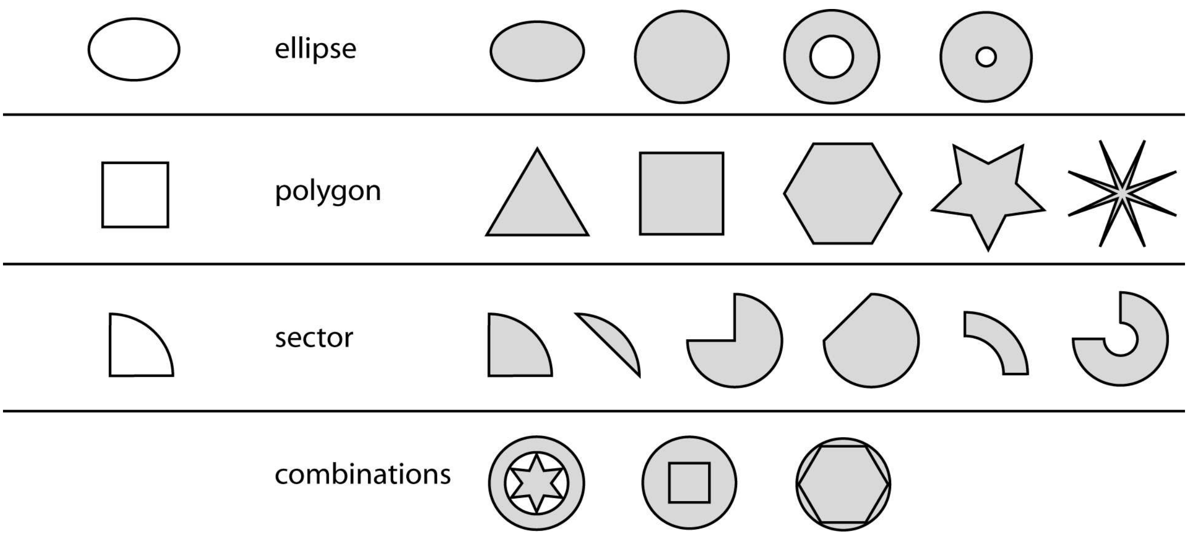

Figure 10: Graphical primitives of simple map symbols

The *ellipse* has the construction properties position and two radii. If the radii are equal in both directions, an ellipse with a circular shape is created. To create the special "circle ring" shape an inner radius needs to be applied (between zero and 100 percent of the circumference). This inner radius can be circumscribed as the intersection of two circles or ellipses).

The *symmetric polygon* has the construction properties position, radius of the circumference and the number of edges. Triangles, squares, pentagons, etc. can be derived from this shape type. A special shape is the star, which needs the radius of a second inner circle as a further property (figure 11).

Figure 11: Construction properties of a star symbol

As a third graphical primitive the *pie sector* has the construction properties position, radius as well as an angle and a start angle. Special shapes are a ring sector (intersection of two pie sectors, applied with an inner radius) and a pie sector without a connection to the center.

With a few transformations (rotate, translateX, translateY, scaleX, scaleY) entirely different map symbols can be created.

Arrangement principles

The graphical primitives described above can be arranged inside of the map symbol with two different arrangement principles.
First, simple geometric map symbols can be arranged by *overlaying* different shapes centered on top of each other.
Second, the graphical primitives can be arranged in a *grid* using the repeated symbols method. Therefore, each primitive of this method represents an equal amount.
Independent of the arrangement inside the map symbol the symbol expresses only one positive data value.

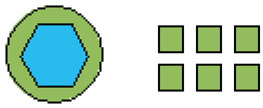

Figure 12: Primitives arranged centered and overlayed (left) and in a grid (right)

Data directions

The created symbol can be scaled according to the data. For simple map symbols only two directions are possible (figure 13):

- in one direction
- around the center of the point of reference (only for pie sectors)

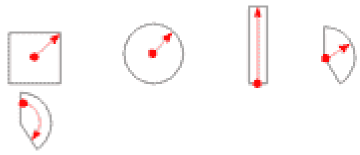

Figure 13: Data directions of a simple map symbol

Example: Construction of a proportional map symbol

1. Choose a graphical primitive.
2. If necessary, choose more graphical primitives.
3. Scale the map symbol according to the data.

In the following example a circle and a square are combined (arrangement principle: centered and overlayed) and then scaled area proportional in one direction according to the data (figure 14).

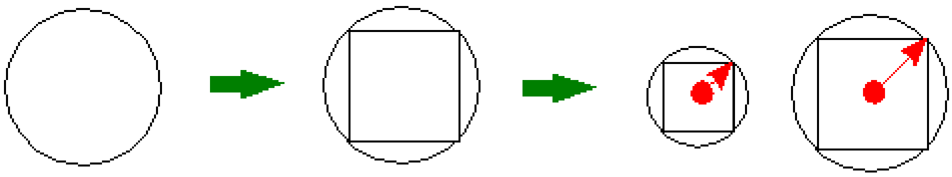

Figure 14: Example of a simple map symbol construction

3.3.2 Diagrams

Diagrams are used to visualize more than one data value related to one coordinate point. An analysis of the given data is necessary to generate a correct diagram. An interesting observation of the diagram construction are the number of data values per coordinate point and whether they can be summarized.

Graphical primitives

Diagrams have five graphical primitives, the three shapes described above, a point and a polyline. In only a few cases the potential primitives fit the arrangement principles. Therefore a selection and limitation of choices is necessary.

The *point* has a position, described by two or three coordinates, and an extension as a construction property. So, value pairs or value triples are needed to use it.
The *polyline* connects different points. To emphasize the polyline and hence silhouette it against the map background the subjacent area can be drawn as a pseudo-area.