About the applicability of interactivity for selected methods of thematic cartography

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Abstract

Interactive applications play an important role in the age of multimedia. Each application has to be interactive nowadays in order to meet the current user expectations. The same holds true in the fields of cartography. Each electronic map or electronic atlas has to offer interactivity. But does each cartographic presentation on screen, especially thematic maps, meet the requirements for being an interactive application? In order to find answers to this question the consideration of the context of cartographic methodology and applied interactivity function, especially on thematic maps, has to be analyzed and evaluated. To find indications on the efficiency of applying interactivity on maps two examples of cartographic methodology are chosen for demonstrating the context.

1 Introduction

The goal of cartography is the efficient transmission of spatial information. Maps can be seen as tools, developed by cartographers, to serve this goal. By adding new attributes to maps cartographers try to improve the map's ability to serve as a useful tool. Interactivity, as an attribute of modern digital maps, can be seen as a major improvement in terms of making maps more efficient tools for transmitting spatial information. It can be argued, that this is because interactivity enlarges the restricted information transmission potential of graphics and enables a development towards more individuality in terms of considering specific user needs. It can also be argued, that interactivity with maps is an improvement, as they better conform to the way we communicate and gather information.

This paper deals with the main conditions and developments of interactivity by trying to analyze map components and functions, especially by selected methods of thematic mapping. It also addresses some selected topics concerning the consequences for the cartographic design and visualization processes.

2 General aspects of interactivity with maps

The process of cartographic information transmission is determined by cartographic models even in an interactive environment. Computerization in cartography has led to the development of interactive cartographic information systems (CIS), which are increasingly demanded by users due to the fact, that technologies and media like the Internet or mobile wireless information devices offer more and faster access conditions and availability to services offered by such systems. As a matter of fact, this development leads to a "crisis of usage" of interactive cartographic information systems. This has to be seen because of the gap between expectations of common users and the possible functionalities of maps serving as an interface or result of interactions with CIS. The development of such a crisis is based on the fact, that an integrative context of interactivity and cartographic methodology is missing.

Therefore, this work deals with selected theoretical concepts of applying interactivity to the process of mapping in a methodical context. Interactivity offers the general advantage of enabling a linked form of data presentation, where the access and exploration of more detailed and/or map element related data is possible. Interactivity offers also the possibility to support the information transmission, which is carried out by map graphics only. The applying of these characteristics into a technological environment, where the permanent actualization of data is possible and/or location/time-independent distribution and access conditions to cartographic presentations are theoretically possible, is often seen of many as a "renaissance" (Taylor 1994), or "change of paradigms" in cartography (Harbeck 1996, Müller 1997, Peterson 1999, Cartwright and Peterson 1999).

This perspective is based on the changed role of map users, which have to become active in order to control the system's actions. The user's controls can only lead to successful information transmission results, if the cartographic information systems can offer and enable methodical correct actions and/or results (maps). Methodical correct interactions with CIS are possible, if the inherent characteristics of maps and the inherent implications of cartographic methodology on the suitability of applying interactive methods on map elements are considered.

The main questions in the context of the described issues can be summarized as:
- How do the inherent characteristics of maps influence the suitability of applying interactivity on maps?
- Is an user-defined control of parts of map design or visualization process in the context of cartographic methodology possible?
- Which innovative technology environments are available, which can offer additional conditions of map distribution and usage?

The methods used to answer the main issues are the analysis of the inherent characteristics of maps, the analysis of aspects of interactivity in a human-computer-interaction context in general and the interaction with cartographic information systems especially, the analysis of inherent implications of cartographic methodology to the suitability of applying interactivity.

2.1 Inherent characteristics of maps

In order to understand the role of interactivity for the cartographic information transmission the context of inherent characteristics and attributes of cartographic representation has to be considered. Cartographic visualization can be characterized by the fact, that although a scale-dependent restriction of information transfer takes place, a visual perceivable symbolization has to be obtained. This condition leads to a number of consequences for designing the information representation, generally known as cartographic generalization, which includes as a consequence, that every secondary model (like a map) has to differ from a primary model (result of data access methods) in terms of changed, heterogeneous and incomplete model geometry and semantics. This has to be seen as a result of the inherent necessities by using graphics as media for transmitting spatial information:
- a scale-related representation of objects cannot be maintained
- a not-scale-related representation of objects requires inherent bigger representation space which can lead to partly or complete overlaps of object representations
- for obtaining visual perceivable and graphical harmonized representations a shift and displacement of map elements is necessary
- an aggregation of objects takes place, if shifting of objects is not enough for solving overlapping problems
- a selection into represented and non-represented objects has to take place, if aggregation and shifting are not enough for solving all overlapping problems

Due to these processes, generally known as cartographic generalization, scale-dependent graphics have inherent characteristics, including geometry and semantic changes. Therefore the information transmission potential of map graphics is limited. In order to overcome these limitations the applying of interactivity can be seen as an important progress.

2.2 Methods of interactions with/via maps

Interactivity can be seen as a tool to overcome these inherent limitations of map graphics to transmit spatial information. It can be described as an interactive map, if an exploration, modification or a definition of a query, for the purpose of individual acquisition of information, is realized. Such an acquisition of information is executed in the form of additional or different ways of presenting the information with the goal of a more appropriate understanding.

Hence it follows that interactivity presupposes that an action is executed. If a referred reaction follows that action, then one can speak of an interaction. The possibilities of the interaction with maps or map elements consist of pure graphic modifications by the user up to the access to data bases or analysis tools. The limits of interaction possibilities are defined by the implemented reactions, which are actually provided by the cartographer.

Interaction possibilities are categorized in different ways (compare the approaches of Silwester 1998, Crampton 1999, Strobl 1999). To interact with or via a map / a cartographic information system could include the following explore or browsing functions due to Gartner (2000):

A. user-defined exploration and browsing of maps, map elements or via map elements
- exploration of information, which is implicate transmitted by map graphics
    - exploration and browsing of sign/symbol meaning
    - exploration and browsing of attributes of symbolized object
    - exploration and browsing of symbol geometry
    - exploration and browsing of reference geometry
    - exploration and browsing of information due to combination of implicit transmitted information

- exploration and browsing of information, which is not implicit transmitted by map graphics
    - exploration and browsing of attributes of map objects, which are not part of map graphics
    - exploration and browsing of primary data
    - exploration and browsing of additional data, which should be displayed as part of the map graphics

B. user-defined control on views of the map
    - pan (change of view)
    - zoom
    - selection of pre-defined and harmonized map elements
    - user-controlled visualization algorithms

C. user-defined control of map creation
    - selection of pre-defined visualization algorithms
    - due to personalization functions (e.g. personal profiles, location based services)

The efficiency of applying these functions on maps has to be seen in close relation to the cartographic methodology used for the map creation. Some of the functions can not - or only partly - be applied or used when a particular cartographic method has been used. In the following chapter this context is discussed on selected methods of thematic cartography.

3 Evaluation of applying interactivity on selected methods of thematic cartography

Two main questions are of interest when evaluating thematic methodology with regard to the potential of interactivity:

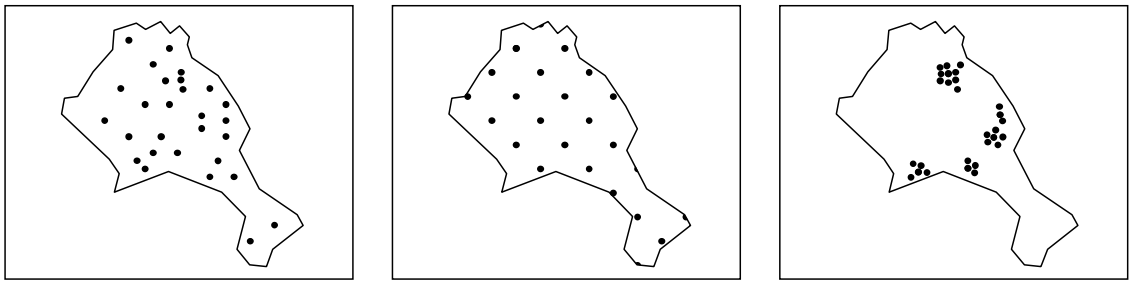
- Has to be something changed in methodology for thematic maps on screen?
- What kind of interactions are possible and will benefit the user?

First it has to be proved, if the evaluated cartographic method to display statistic data is generally applicable for maps on screen. It is indisputable that the basic graphical principles have to be adapted for the specific requirements on screen. That means, for example, that minimum sizes and distances have to be increased for a readable graphic. But it does not imply inevitably, that even the graphic or graphic elements have to be changed.

The most serious disadvantages of screen devices are still the size and the resolution (cp. Ditz 1997, Arleth 1999). It is only possible to show a map either at a small scale or just a detail of the map. The only way to compensate this lack is to provide maps on screen with interactivity. Especially thematic maps on screen are predestinated to support the user with analysis tools to get advanced and detailed information of statistic data, that are difficult or impossible to obtain from printed maps. One example is the presentation of a genesis that can only be realized with a series of maps in printed form but as a computer animation on screen (cp. Dransch 1995, Kraak et. al. 1997). Excluded from the discussion of interaction shall be map navigation and orientation as well as the change of graphic attributes like shape, size or color. The focus in this article is set on functions for information access and data analysis.

3.1 Dot maps of population distribution

The technical realization of dot maps on screen as a prerequisite for user interaction is described in Ditz (1999). Figure 1 shows the effects of different methods for placing dots. There is no doubt that only an automated random placement of dots considering further topographic elements at an accurate scale leads to a graphical result necessary for an ingenious analysis. Though the method of dot maps is the only way to present distribution phenomena, the use and interpretation of such a thematic presentation is complex, especially for users who are non-experts in cartography. Therefore it is indispensable to append an introduction of the production of dot maps to understand the potential and the limitations of this powerful cartographic method.



a b c

Figure 1. Differences between the possibilities of generating a dot map
a random placement
b regular placement
c random placement in consideration of topographic situation

The methodology of dot maps on screen does not necessarily implicate major changes for the graphical design for the output. Small squares would result in a better graphical representation because of the pixel structure of graphic devices, but the algorithm of the automated placement would fail. The minimum distance query to already placed dots can only give constant proper results independent of the positions of the elements when using circles.

Dot maps are only partly suitable for user controlled interaction of map creation. A user interaction for dot maps is the decrease of the dot value, as shown by Ditz (2000). This implies the change of scale combined with an intelligent zooming, that means the enhancement of the map content of the topographic base map making sense for that specific scale. In addition to the change of scale the automated placement of dots has to be renewed with the possibility to consider the enhanced map content within the algorithm of the placement. The change of the scale must also be accompanied with an adequate refinement of the quality of the statistic data. It does not make sense to use a topographic base map showing the settlement as a point signature combined with statistic data referenced to blocks and vice versa.

Another useful method, that should not be missing in a cartographic information system, is the search for a settlement and the display of the corresponding distribution of population. Thereby the real value of the population should not be determined by counting the dots but rather displayed as an additional text information. In general the counting of dots in an irregular area as the real power of a dot map is 'getting lost' because of the possibility to determine and display the exact values. On the contrary, by the use of such a function a precision would be implied which is neither given by the accuracy of the placement not by the quality of the used dot (figure2).

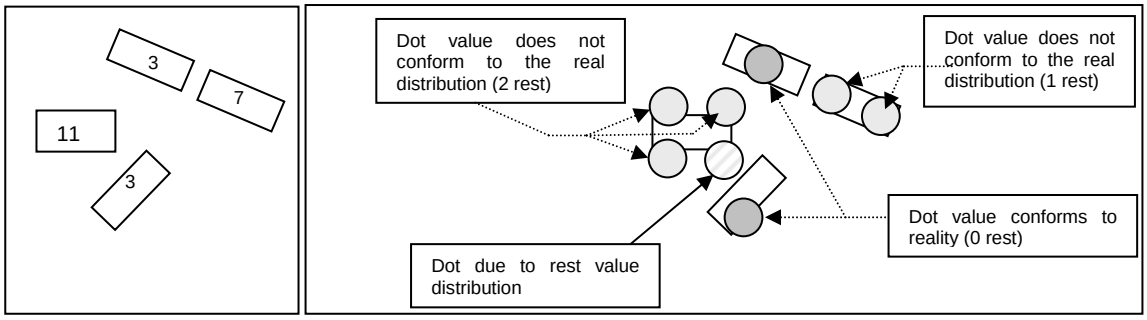


Figure 2. The interactive exploration and browsing in dot maps is limited to the exploration of the value of the dots. The dot value is not representing the real value of a subject. Therefore the house with 11 inhabitants is represented in the dot map with dots representing a total value of 12 inhabitants. The interactive exploration of the inhabitants via the representation of the house would give a discrepancy to the explored value of the dots.

3.2 Proportional point symbol maps

This cartographic method to display discrete absolute values is a simple technique easily understood by most of the map readers. Almost all GIS and cartographic programs offer functions to generate such maps. Figure 3 is a good example of a poor map design to show the difficulties of producing such a point symbol map on screen. The first demand for a better and readable map design is the use of transparent colors, as it is realized for example in the Atlas of Switzerland (Bär and Sieber, 1997). The left part of figure 3 shows symbols that cover up most of the topographic base map not only due to a poorly chosen symbol scale. Thus the localization of the symbol is almost impossible. Only mono-thematic maps without any hill shading can be realized when using smaller symbols as shown for instance in the right part of figure 3 and when the topographic base map is drawn in front of the symbols (not realized in that

figure).

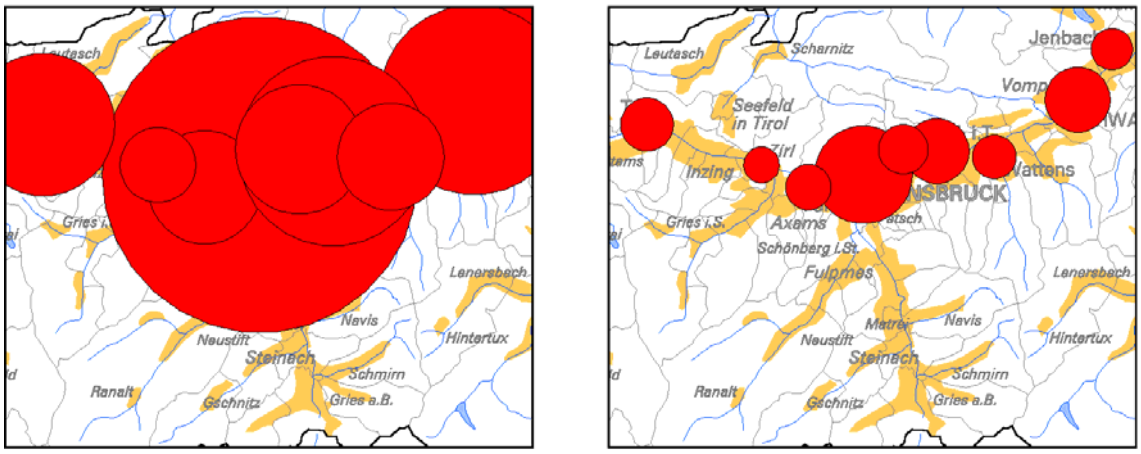


Figure 3. Examples of proportional point symbol maps with different symbol scales (partial display of population values)

Absolutely essential is a legend on a printed proportional point symbol map showing the underlying kind of symbol scale. However, a study about the estimation of symbols has shown that errors in the analysis of such symbols must be expected (Dent, 1996). A legend is also necessary for maps on screen but it does not have that importance as on printed maps because interactivity facilitates the exact calculation of the value shown by the symbol. A mouse click on a symbol or a mouse over function submits the user the exact value.

A wide range of statistic data values with only few high values poses a problem for the design of point symbol maps. In that case a logarithmic symbol scale, situation dependent and complex in generation but not feasible for automation, is the solution for this problem. The use of range-grading symbols offers an alternative for the generation of symbol maps on screen. Therewith, the disadvantage of a poor resolution and the drawback of estimating the size - and therefore the value of a symbol - could be obviated. For that reason approximately 4 to 5 classes with non-ambiguous symbol sizes and associated map legend guarantee a first and quick comparison of statistical data.

A further potential of interactivity in thematic cartography on screen is the facility to compare different values of locations necessarily and moreover mainly not located nearby. To offer a graphical comparison it is essential to use now value proportional symbols even when range-graded symbols are used for the symbol map. The presentation of this graphical comparison can be made in an legend area of the program or in an additional window popped up over the map. The layout of the graphic could be separated like the left part of figure 4, or an overlay of both symbols with a clear distinction as it is shown in the right part.

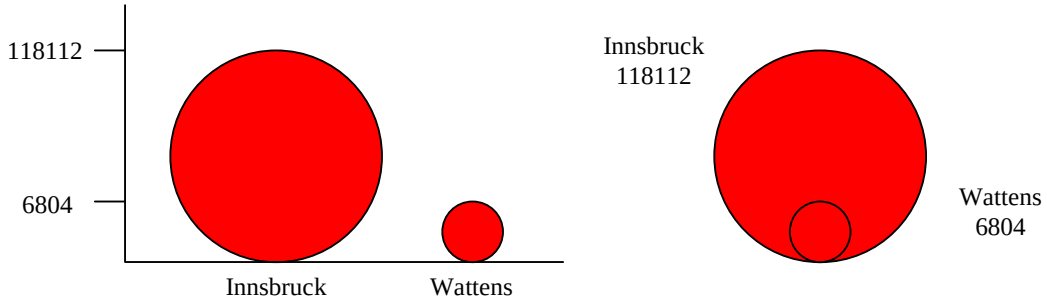


Figure 4. Different kind of graphical comparisons of statistic values

Although a complete abandonment of the correlation of the graphical representation (by the variable "symbol size") and the concrete individual data value could be possible in an interactive environment, it is nevertheless not recommendable due to cartographic communication principles in terms of efficiency of spatial information transmission.

4 Conclusion

The conception, realization and usage of interactivity with maps has caused a number of fundamental changes in cartography. In order to better fulfil the overall goal of cartography and to efficiently transmit spatial information, cartographers have to deal with both the critics of internal paradigms about their goals and the way they try to achieve them with theories and external changes due to new methods, algorithms, technologies and tools.

The implications of applying interactivity on maps include:

1. the role of the map user is changed
2. the usage of already prepared information is supported
3. the usage of additional information to already displayed map elements is possible
4. the user-defined control on specific parts of map creation is partially possible
5. pre-condition for a personalization of cartographic communication
6. a time- and location-independent usage of digital information systems can be achieved
7. the exploration and browsing of permanently updated and visualized data-sets becomes more efficient possible

Using interactivity can therefore be seen as a benefit for cartography. This is not because interactivity gives an increased potential for making maps, but possibilities to overcome restrictions, which have been ruling “cartography” for a long time. Interactivity is seen often (Peterson 1995, Crampton 1999) as the major key between the cartographer and the user and between the task of modeling data and visualizing information. The development of interactive applications by evaluating and gaining technical, methodological and theoretical skills will therefore become a major topic for future cartographic research and education. In this context a close correlation of cartographic knowledge and methodology and interactivity methods and techniques have to be considered in order to achieve valuable results, which has been shown on two selected examples of thematic cartography.

The following two examples demonstrate, that cartographic methodology of printed maps is adaptable to maps on screen nearly without any serious changes but also with the same limitations. The task of cartographers is the development and programming of analytical functionality in multimedia environment

(Bär and Sieber 1999). Important for the user is the support with information on how to use this tools and about the risks of misuse. Furthermore the cartographer as the expert should consider about which interactions and functions make sense and which restrictions are useful to guarantee a satisfying result of analyses (Kelnhofer and Ditz, 1997).

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