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Effectiveness of dynamic label transitions

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Abstract

Today, dynamic and interactive maps are found everywhere on the Internet. Efficient map labelling algorithms have been a subject of research for many years now. The investigation of the user-side of the problem is often neglected. A user study is planned to get an insight in the cognitive processes of users while handling these interactive maps. In this user study two hypotheses are evaluated, using the eye link. With this method the movements of the users' eyes are monitored, which is closely linked with his moment-to-moment cognitive processes.

Keywords: *Interactive cartography, cognitive maps, map labelling*

Introduction

Today, dynamic and interactive maps on the Web are more popular than ever. It is estimated that more than 200 million of maps are distributed through the internet on a daily basis; this is more than the number of paper maps printed each day (Peterson, 2003). Websites like MapQuest and GoogleMaps are two of the most popular groups of web applications using this kind of maps. This popularity, and consequently the number of users, has rapidly grown over the past few years (see Table 1).

Date	Number of Unique Visitors	Source
1999 (November)	4 677 000	***van Elzakker, 2001***
2000 (March)	7 598 000	***van Elzakker, 2001***
2002 (March)	18 000 000	***van Elzakker and Poppe, 2002***
2008 (May)	**47 500 000**	***Mapquest, 2008***

Table 1: Rapid growth of unique visitors for MapQuest

One important issue for the dynamic and interactive maps is the automatic placement of labels. In cartography, these labels are some of the most important elements on the map. A label can offer the user much more information than a symbol can. They are also important reference points, facilitating the users' orientation. Consequently, the quality of a map greatly depends on the quality of the label placement.

Label placement algorithms for interactive maps have to be able to handle specific constraints in contrast to the static placement algorithms used in the production process of paper maps. The most important constraint is the strict time constraint. Since a new label placement has to be (re)calculated after every user interaction, calculation times over a second are unacceptable. A great number of studies have been devoted to find a fast, efficient label placement algorithm: Christensen et al., 1995; van Dijk, 2001; Yamamoto et al., 2002.

While researchers were concentrating on finding an efficient label placement algorithm, the user-side of the problem was overlooked. Algorithms not only have to be efficient, they also need to be effective. A very fast, efficient algorithm is useless to the user if he cannot process the results of it. Users store information mentally in a certain way. In case of geographical information this is called a mental or cognitive map. To be able to create an effective algorithm, insight in this cognitive map and the cognitive processes of users are needed.

Some user studies have already been conducted about the usability of interactive and dynamic web maps (Heidmann et al., 2003; Kramers, 2008; Ladniak and Kalamucki, 2007; Nivala et al., 2008), but none of these studies have focussed on the effectiveness of the label placement algorithms. In the first part of this paper, two hypotheses concerning the automatic and dynamic label placement are discussed. To test these hypotheses, a user study is planned in the coming months. The methods used in this user study are described in the second part of the paper.

Efficient and effective label transitions: two hypotheses

The first hypothesis considers the number of labels which needs to be recalculated. Often, users want to explore the surrounding area of the current view. Panning is a handy tool which is used to accomplish just that. By using this pan operation, the user moves the current position of the view over a certain distance. As a consequence, certain labels will vanish from the view whereas others pop up. While exploring the area, users want to keep a part of the previous view visible within the new one in order to reconstruct the relative positions of objects to each other.

Current label placement algorithms do not consider this overlap between two subsequent views: the positions of all labels within the new view are (re)calculated. The first hypothesis does consider this overlap: "*labels which stay within the view after an interaction should not be recalculated*". Consequently, only the labels near the border of a view may change position instead of all the labels across the view, thus saving precious calculation time, since fewer labels need to be (re)calculated (see Figure 1).

For the user, on the other hand, it may be easier to reconstruct the relative positions of objects (with a label attached to them) after a pan operation if fewer labels are repositioned. The user was already familiar with the positioning of the labels (and consequently the related objects) from the first view. When a significant number of labels is suddenly located in a different (relative) position, it may be difficult for the user to process all these unnecessary changes. It would be much easier if that part of the view, which is also visible after the interaction, would remain untouched as much as possible.

This first hypothesis is integrated within the planned user study. The aim of this part of the study is to determine if applications, in which this first hypothesis is applied, are more effectively processed by the user. The methods used to obtain these results are discussed in the next section.

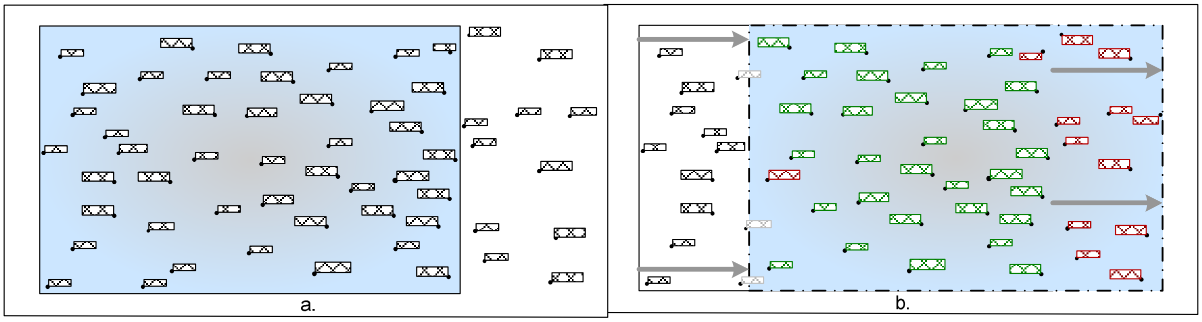
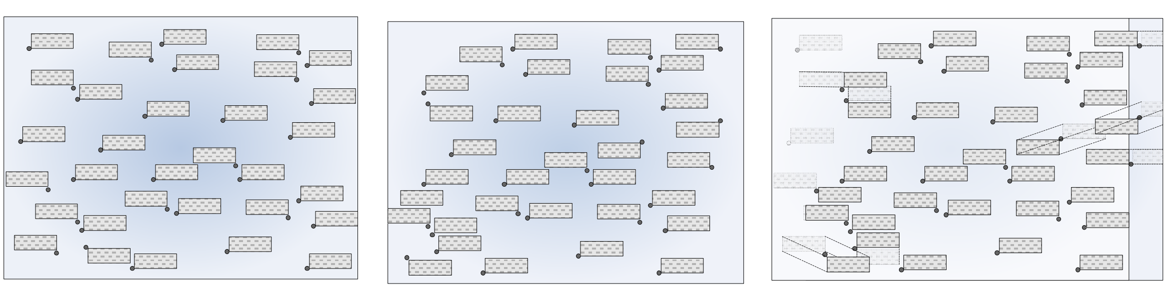


Figure 1: Only the labels in red need to be (re)calculated

In most applications today, labels make a discrete movement when they change position: they ‘jump’ from one position to another. This may confuse the user because the relative positions of the labels abruptly change, making it for the user very hard to reconstruct the relative positions of the objects, linked to these labels. When a great number of labels suddenly changes position, the user cannot keep track of every label in order to remember what its original position was and how it moved.

In general, users can process continuous movements more easily because they can follow the path along which the object moves. This is exemplified in Figure 2, in which the original view is presented by the picture on the left. View *b* and *c* are the resulting views after a pan operation to the right. In the case of view *b* the labels made a discrete movement whereas a continuous movement is depicted in view *c*. This last view thus shows much clearer which labels changed position and how they changed. The second hypothesis is related to this way of ‘transferring’ a label to its new position after an interaction: *“if the relative position of a label needs to change after an interaction, it has to be visualized in a continuous way”*.

View *c* in Figure 2 also illustrates another issue related with this second hypothesis. Labels are – temporarily – allowed to overlap objects and other labels. Generally, overlap between labels and object reduces the quality of the map significantly because the labels become illegible. Because of this fact, the overlap is only allowed temporarily: only during the transition subsequent to an interaction. The path along which the label moves is a straight line, starting at the initial position at the moment of the interaction and ending at the new position after the transition of the view.



a) *b)* *c)*

Figure 2: Examples of discrete movements *(a* to *b)* and continuous movements *(a* to *c)* with label transitions in subsequent views

Methods

In the near future, a user study is planned to get an insight in the cognitive processes of users while working with an interactive, dynamic map. These insights will help map developers to construct more efficient and effective maps. Different methods exist to conduct a user study: observations, interviews (structured and unstructured), questionnaires, thinking aloud method, e.g. (van Elzakker, 2004). A suitable method needs to be selected, depending on the aim of the study.

The most frequently method used in a user study is a questionnaire. In this questionnaire a user can express his preference for one method over another, for example on a Likert scale. But this is a very subjective method as users tend to prefer the method they are familiar with. This does not necessarily mean that the new method is less effective.

To avoid this problem and to get a better insight in the cognitive processes of a user during the use of maps in an objective way, the movement of his eyes is monitored. Rayner (1998) stated that "considerable data have been collected that demonstrate that eye movements are intimately related to the moment-to-moment cognitive processing activities of the readers." Although there are several differences in eye movement during reading and a visual search, the main principals remain the same.

In this study the two hypotheses described earlier are tested. The combination of these two hypotheses results in four different 'types of transitions' which need to be considered:
*discrete movement of labels, only near the border,
*discrete movement of labels, everywhere,
*continuous movement of labels, only near the border,
*continuous movement of labels, everywhere.

For every type, twenty different dynamic maps are constructed, using the Scalable Vector Graphics file format (SVG). The use of SVG is essential because it allows the visualisation of continuous movements of objects, the labels in this case. Every map consists of a set of point objects and labels. Not every point in the map is linked to a label, but the number of labels in each view is relatively constant, guaranteeing an objective comparison between the different maps.

The resulting eighty maps are split up into four groups (see Table 2) in order to bypass some potential problems:

1. *Learning*. Every type is applied to a region, resulting in 4 maps of the same region with each a different type of transition. When the same region (but with a different type applied to it) is presented for the third or fourth time to a user, he might remember the position of certain labels, resulting in inaccurate results. To prevent this learning process, the same region will only be present once in the same group.
2. *Time*. If the study was not split into different groups, every subject had to go through the eighty maps, resulting in testing times of several hours and thus reducing the quality of the results. By using four groups, every subject only has to test twenty maps, keeping the different tests manageable.
3. *Results*. In every group, only two of the four types are included, resulting in faster initial results (but limited to these two types).

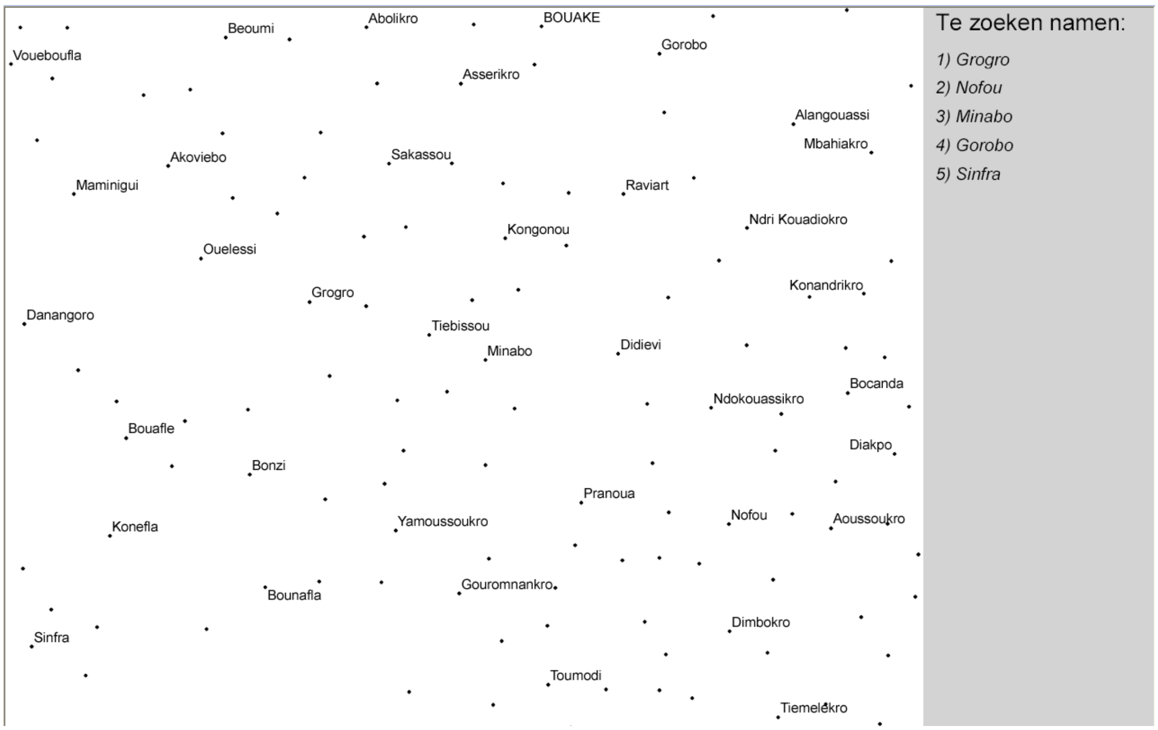
region	group1		group2		group3		group4	
afr	Discrete	Total	Discrete	Border	Continuous	Total	Continuous	Border
alberta1	Discrete	Total	Discrete	Border	Continuous	Total	Continuous	Border
alberta2	Discrete	Total	Discrete	Border	Continuous	Total	Continuous	Border
algeria	Discrete	Total	Discrete	Border	Continuous	Total	Continuous	Border
angola	Discrete	Total	Discrete	Border	Continuous	Total	Continuous	Border
burkina	Discrete	Total	Discrete	Border	Continuous	Total	Continuous	Border
chad	Discrete	Total	Discrete	Border	Continuous	Total	Continuous	Border
ethiopia	Discrete	Total	Discrete	Border	Continuous	Total	Continuous	Border
gabon	Discrete	Total	Discrete	Border	Continuous	Total	Continuous	Border
ghana1	Discrete	Total	Discrete	Border	Continuous	Total	Continuous	Border
ghana2	Discrete	Border	Discrete	Total	Continuous	Border	Continuous	Total
guinea	Discrete	Border	Discrete	Total	Continuous	Border	Continuous	Total
icoast	Discrete	Border	Discrete	Total	Continuous	Border	Continuous	Total
mali	Discrete	Border	Discrete	Total	Continuous	Border	Continuous	Total
mozambique	Discrete	Border	Discrete	Total	Continuous	Border	Continuous	Total
niger	Discrete	Border	Discrete	Total	Continuous	Border	Continuous	Total
nigeria1	Discrete	Border	Discrete	Total	Continuous	Border	Continuous	Total
nigeria2	Discrete	Border	Discrete	Total	Continuous	Border	Continuous	Total
sAustr1	Discrete	Border	Discrete	Total	Continuous	Border	Continuous	Total
sAustr2	Discrete	Border	Discrete	Total	Continuous	Border	Continuous	Total

Table 2: Structure of the four groups

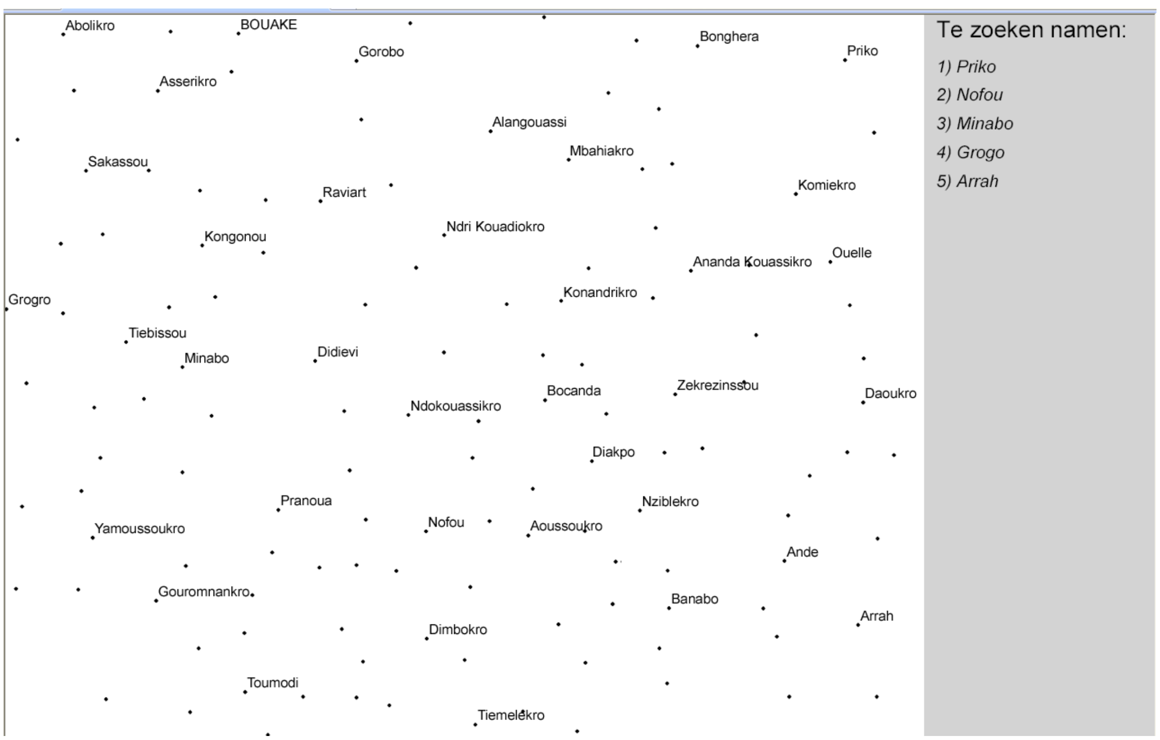
The general structure of the user study is as follows. The subject will be presented twenty dynamic maps. In the initial view, which remains static during 90 seconds, the subject has to find five names (See Figure 3a). After these 90 seconds there is a transition to a new view, which remains - at the maximum - visible for 120 seconds. Also, in this second view, the subject has to find five names, of which already three were present in the first view (See Figure 3b). When the subject finds these last five names or when the time limit is exceeded (the 120 seconds), the test starts again with a new region and, possibly, with a different transition type.

Conclusion

While users perform tasks on 4 different demo applications their cognitive processes can be monitored through their eye movements. In these demo applications, the two hypotheses are embedded in such a way that their effectiveness can be determined. The outcome of this user study allows us to create both more efficient and effective label placement algorithms for interactive and dynamic web maps.



a)



b)

Figure 3: Extract from the user study

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