Temporal Classification of Events on Map Animation

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Abstract—Colour is often reserved for the visualization of attribute information in cartography. It has been used to visualize the flow of time, usually with continuous change.Our goal was to use the colour to visualize the temporal behaviour of the data, which would be practical when the number of events per time unit varies strongly inside the data set. In this study, we experimented with this method by colouring the events on the basis of the growth and decreasing of the number of events. An online user test was carried out in order to examine the potential of this method. The test proved that the users found the method insightful and it helped them to interpret some types of behavioural patterns. This approach can be seen as a temporal classification method, and it would be a valuable addition to the toolkit of visual analysis.

Index Terms—map animation, temporal classification, user testing, visual analytics, spatio-temporal

1. Introduction

Map animation is an effective method to visualize temporal change. It uses the fourth dimension, time, to intuitively visualize the very same dimension of the data. Among its other advantages, it leaves the most powerful visual variable of cartography, colour [1], free for visualizing attribute information.

In static maps, colour can be used to visualize time flow. Typically, the colour of the objects on the map changes smoothly from one hue to another. In this way the temporal distance between two objects can be estimated, or at least compared with others, by the difference in those hues.

If we combine these two methods, an animated map and a coloured timescale, we end up with a situation where two visualization methods mark the same variable. This can be advisable for example when the new objects appearing on the map must be very clearly noticed, or the time stamp of each object must stay visible when the data is presented cumulatively. To optimize the use of this double variable, the colour should visualize the phenomenon in the best possible way.

1.1. The Relationship between Ordinal Attribute Information and Time

With thematic maps, the classification of the data pursues to form data classes so that the objects inside each class are as homogenous as possible, and the differences between classes are as big as possible [2]. The classification method should always be selected carefully so as to provide a realistic image of the phenomenon to the user.

If the coloured animation shows, for example, information from one month with one colour and from the next month with a different colour, the result is analogical with the situation where attribute information is classified with the equal intervals method. However, it does not take into account the temporal distribution of the dataset. 4This inspired us to examine whether some other classification method than equal intervals would correspondingly produce better results when visualizing the temporal aspect of the data.

1.2. The Aim of the Research

We created two different animations, one where point-type events were classified with a natural breaks method based on the temporal structure of the data set and another where the events changed their colour smoothly during the period, and performed a user test with those animations. The aim was to find out whether the users understand this kind of visualization, if they find it informative, and what kinds of analysis tasks it might suit.

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The details of the classification method that was tested and its visualization are explained in Chapter 2. The user testing of the method and its results are presented in Chapter 3. These results are discussed in Chapter 4, followed by conclusions in Chapter 5.

2. Temporal classification of the data

A phenomenon can behave differently in different periods of time. In these cases, smoothly changing the colour with time may not be the most meaningful way to use colour. There can be periods with very few events or none at all, and when the number of events starts to grow, it can happen slowly or more suddenly.

To visualize these changes in temporal behaviour, we suggest a method which classifies the data according to changes in its behaviour. When the number of events per time unit (for example, day) is presented in a diagram, the natural breaks in the behaviour can be found out with the fitting of a line (Figure 1). When the gradient of the line is positive, there is a growing tendency in the phenomenon, and a negative gradient marks a decreasing tendency. When the gradient is 0, the phenomenon is steady, but it does not show whether the actual number of events is more or less than in other periods with steady behaviour.

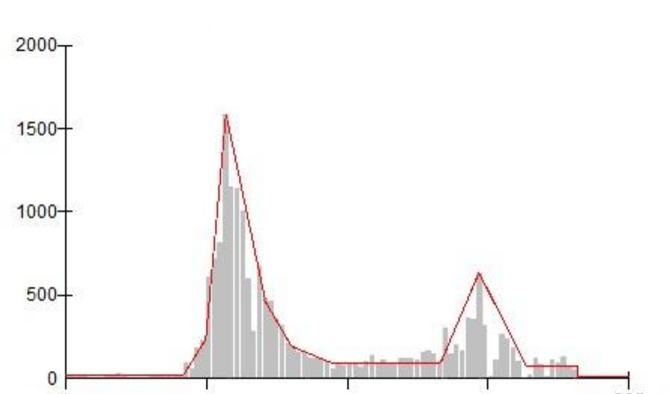

Fig. 1. The diagram shows the number of events per day from a one-year period. The red line is fitted to mark the growth and diminution of the phenomenon. There is a strong peak around day 100 and a smaller peak around day 270. During the summer months (the middle of the diagram) the phenomenon is a little stronger than during the winter, but the slope is 0 in both periods.

As with any classification process, the number of classes can be determined separately with every case. In the simplest version, only three classes are used; increasing, decreasing, and steady. In some cases, it would be necessary to separate slow and fast increasing and decreasing.

2.1. Use of Colour to Visualize the Temporal Classification

The events in each class should be coloured with a diverging colour scale suitable for the phenomenon in question. The middle colour, representing steady behaviour of the phenomenon, should be neutral [2]. If there are more than three classes, the more sheer change should be visualized with a more saturated colour. A smooth, continuous use of colour, based on the slope and without any clear classification process, is also possible.

It must be emphasized that with this method, the colour of the events does not visualize the passing time, and the time stamp of a single event cannot be interpreted from its colour. The colour visualizes the temporal behaviour of the phenomenon at the given moment.

2.2. Temporal Classification on an Animation

This classification method can be used both with static maps and animations. When the classification visualization is used to make an animation, we must define how short the periods are that we want to visualize. In this study, the length of one period was determined to be at least 3 seconds in the final animation. When the total length of the animation was 60 seconds, presenting data from a one-year period, this limited the classification periods to being at least 18 days long. Shorter peaks or dips in the event diagrams were ignored.

To make sure that periods with the same colour and slope are not mixed together, the events of the older period must disappear from the map before the new ones start to show. Therefore the data cannot be showed cumulatively. However, it is possible to use partial accumulation if the time window is adjusted to be shorter than the shortest classification period.

There are some cases where the accumulation of the data is still possible. If the number of classified periods in the data set is small enough, it would be possible to select different hues for all the behaviour periods. By this method a rough estimation of the time stamp of each event can still be read from the map.

2.3. Spatially Divided Classification

Real-world phenomena have a tendency to have variation in both their spatial and temporal behaviour. The temporal classification method presented here can be developed further by taking the spatial distribution into account. By dividing the area of interest into zones and considering their temporal behaviour separately, we can get an even more precise picture of the phenomenon. These zones can be drawn, for example, by the assumed spreading direction of the phenomenon, or, in the case of a single event and its effect, growing circles around the trigger event.

With this method, the number of temporal classes, classification, and colouring are created in the same way as with the previous example. In the phase of line fitting, the events of each zone are considered as a separate data set. When the spatially districted classification is visualized on the animation, we can, for example, see that the phenomenon continues to spread in the outer circle while it is already subsiding near its starting point.

The disadvantage of spatial division is that it can split dense spatial clusters into different zones. This could be avoided by using an algorithm which searches for the best division curve, inside some predefined range, between the zones.

3. User testing

We carried out a user test of the temporally classified animation via the Internet. The aim of the test was to validate the usefulness and understandability of the method. The test users had experience in the field of the phenomenon presented in the animation.

3.1. Test Data and Animations

The data set used in this test was a set of bird observations: all observations of grey and black geese (genera *Anser* and *Branta*) in Finland from the year 2011. Geese do not winter in Finland, except some individuals who stay on the southern shore, but they migrate there to nest in the springtime. The total number of observations in the data set was 18,175. The area was divided into five zones by lines with an east-west course (Figure 2). The events from each zone were classified into three classes according to their temporal behaviour: the colour orange indicated an increasing number of events, purple indicated a decreasing number of events, and grey indicated a steady state. The colours were chosen to be colour-blind friendly [4]. This data set was then played in an animation. The length of the animation was 60 seconds. The events appeared on the base map and stayed visible for about 3 seconds.

To compare the test results of this animation with another, more traditional visualization method, we created another animation from the same data set. In this animation, the colour of the events changed smoothly from yellow (January) to blue (December) via orange, red, and purple. Otherwise, these two animations were identical.

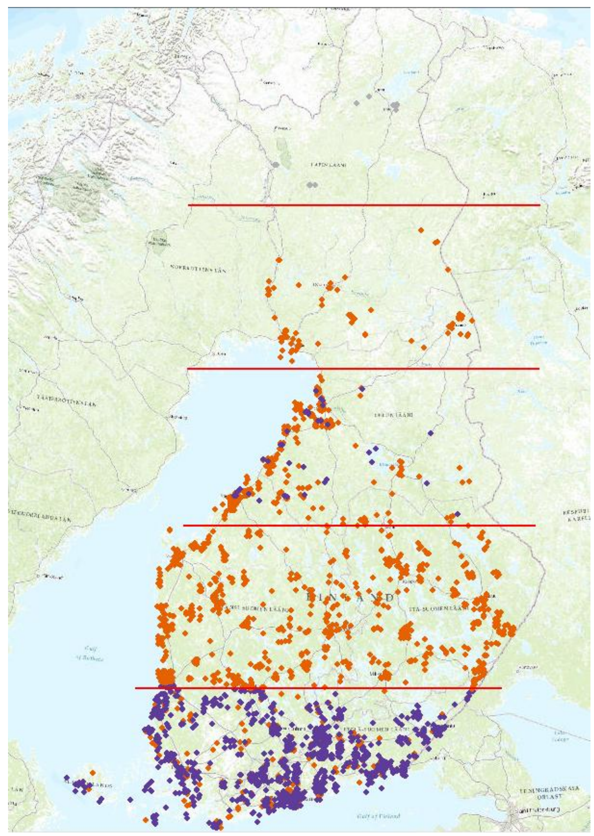

Fig. 2. A screen grab from the animation that was tested with spatially divided and temporally classified visualization. The red lines illustrate the division of the zones and were not visible in the test animation. Basemap: ESRI 2014.

3.2. Test Setting and Questions

A questionnaire was designed to test the interpretation of the animations with the test users. First, the users viewed the animation, and were asked to describe the phenomenon in their own words. After that, a set of 10 claims about the behaviour of the phenomenon was shown. Some of the claims were elementary comparison tasks, with either a spatial subject (“In the wintertime, there are more events in the eastern than in the western part of the area”) or a temporal subject (“The spring migration lasts longer than the autumn migration”). Other claims were synoptic behaviour tasks with a spatio-temporal subject, e.g. “The autumn migration is already over in the north before it arrives in the south.” There was also one comparison task with a density subject: “The spring migration is stronger than the autumn migration.” [5] The test users were asked to decide whether those claims were true or false, and to state how many times they viewed the animation in order to complete this task.

The comparison of the results of the temporally classified animation and the reference animation was enabled in such a way that the test users saw both animations and answered similar questions. To avoid the learning effect and the tendency to promote the first one, half of the user group saw the reference animation first, and half saw the temporally classified animation first.

In the last part of the test, the users had a chance to give free feedback on both animations. They were also asked to mark their preferences between the two animations, with respect to for example, which one was more informative, understandable, or insightful.

45 test users completed the test. The users were twitchers with a lot of experience of bird observation. The median of their age was 49 and most common age group was 60-69 years. Nine of them were female and 36 male. Their colour vision was tested and three of the test users proved to be red-green colourblind.

3.3. Results

The tests of the two user groups varied only in the order of the two animations, and the results were combined before the analysis. Three indicators were considered: 1) the performance with the claims; 2) the test users’ preferences between the animations; and 3) the free feedback on the animations.

The users’ performance with different types of claims is shown in Table 1. With the classified animation, the users performed slightly better on the tasks which dealt with spatio-temporal or density topics. At the same time, their performance was equally worse with more simple temporal or spatial tasks. When all the tasks were compared together, there were no significant differences in their performance between the animations.

Table 1. The performance of the test users.

	Classified animation			**Reference animation**		
	right answers	not sure	wrong answers	right answers	not sure	wrong answers
Temporal claims	51%	14%	35%	54%	7%	39%
Spatial claims	81%	11%	8%	91%	1%	8%
Spatio-temporal claims	60%	12%	28%	57%	18%	25%
Density claim	80%	11%	9%	73%	18%	9%
All claims average	64%	12%	24%	65%	11%	24%

When the users’ preference between the two animations was enquired about, the classified animation got significantly more positive feedback than the reference animation. Table 2 shows the numbers of each preference claim.

Table 2. The preferences of the test users between the animations that were tested.

	Classified animation	No difference	Reference animation
This animation was easy to understand.	47%	29%	24%
This animation was pleasant to view.	31%	47%	22%
This animation was informative.	47%	33%	20%
This animation was insightful.	44%	44%	11%
This animation was confusing.	18%	47%	36%
This animation was boring.	9%	76%	16%
I liked this animation more that the other.	60%	13%	27%

Free feedback on both animations was collected. The users were asked to give their opinion about the animation. They were also asked what kind of phenomenon the animation would be suitable for, and whether the animation gave them any new information about the migration movement of geese.

The feedback was analyzed by calculating the number of mentions of the following: positive feedback, negative feedback, description of potential use, and offering of new information. The classified animation got more positive and fewer negative comments than the reference animation. It also got a few more mentions about the potential use cases and about offering new information for the user. The user group who viewed the reference animation first and the classified animation second had more positive impressions about the classified animation than the other group, who saw the animations in reverse order.

4. Discussion

The temporally classified animation was designed to reveal spatio-temporal patterns which may not be noticed with traditional animation methods. The test results prove that the temporally classified animation can improve the performance of spatio-temporal analysis tasks. However, at the same time it seems to weaken the performance of simpler tasks. This suggests that the temporal classification method should always be used as a part of a visual analysis toolkit and not on its own. Further evidence for this presumption is that the feedback was more positive with the group who saw the reference animation first. Apparently, they got a better vision of the method as a complementary tool.

While the measurable results from the user test show fairly small differences between the classified animation and the reference animation, the feedback from the test users was encouraging. In several of the feedback comments mention was made of how the classified animation opened up new insights and was interesting, and could be a valuable tool for this kind of visual analysis. This is particularly interesting when we consider the fact that the test users were not professionals in geography, geoinformatics, or computer science, and that the technical skills of the 60-69 age group, to which most of the users belong, vary greatly.

Many of the users also said that the animations did not give them any new information, but more or less confirmed their tacit knowledge about the behaviour of migrating geese. Therefore, our next plan is to complete this study with another test in which the users have experience of visual analysis of spatio-temporal information, but no knowledge about the migratory behaviour of birds.

This method, especially when used with spatial division, needs some a priori knowledge about the data set and task-dependent design for the best use to be made of it. Therefore it is not suitable for pure data mining cases, but rather for the later phase of data analysis.

5. CONCLUSIONS

This study presents a novel classification approach using the temporal gradient of the events. The classification was performed regionally within the data set area to enhance the temporal behaviour of the data. A user test was carried out to test the potential of this temporal classification.

The results showed that the temporally classified test animation provided better results with complex spatio-temporal tasks. The test users gave mostly positive feedback, and they also saw the potential use cases for the temporal classification method. However, the method that was tested led to worse results with simpler comparison tasks. This suggests that it should not be used on its own but rather as one new tool in visual analysis.

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