# Geovisual analytical method for animated map

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## Introduction

With the increasing availability of spatio-temporal datasets, animated maps have been used to explore and represent temporal patterns in geographic phenomena. Andrienko et al. (2003) classifies spatio-temporal information into three categories: existential changes, changes of spatial properties, and changes of thematic properties expressed through values of attributes. Animated mapping technique has been successfully facilitated to represent temporal patterns of those types of spatio-temporal information. However, animated mapping technique has some limitations. Most animated maps are intended to show an intuitive pattern in a spatio-temporal dataset in dynamic form, so its usability is limited to simple and visually perceptible patterns. Also as Hallisey (2005) pointed out, any animated map is designed to convey information its maker intended to present. Interpretation of the map might be restricted to the mapmaker's subjectivity. As the result of usability assessment reported by Ahn (2007), animated map is appraised less useful for identification, comparison, and association tasks, compared to other visualization methods such as temporal coordinate plot and 3D Cube.

Most researches on animated mapping have been focused on how to integrated time in mapping procedure as in time variable (Monmonier, 1990), dynamic variable (Dibiase *et al.*, 1992; MacEachren, 1995; Blok *et al.*, 1999), technical aspects of animated maps (Peterson, 1995; Harrower, 2003), and case studies with spatio-temporal phenomena (Harrower *et al.*, 2000; Harrower, 2002; Frihida *et al.,* 2004). However, little effort has been devoted to develop analytical functionality of animated mapping method.

In this study, we propose a novel analytical animate mapping method to explore a hidden pattern in spatio-temporal dataset. It is based on integration of automated analysis and visualization method as proposed in the context of geovisual analytics.

## Proposed method

This research addresses the use of choropleth classification and its temporal changes for identifying patterns in spatio-temporal phenomenon and classifying changing regions as illustrated in Figure 1. Temporal change of a region's attribute is measured by a time-ordered sequence in which each region's state is continuously recorded as predefined class at each temporal frame in the animated map. This is followed by the similarity measures for "class sequences" of sub-regions. The similarity matrices are generated from the similarity measures calculated by Levenshtein metric method, then used to produce clustered classification map that presents patterns hidden in the history of changing regions. Through a case study on the rate of land price fluctuation of 232 administrative units in Seoul, Korea, 1995 - 2004, the feasibility of the proposed method is tested for the similarity analysis of sequential changes and the clustered classification of changing regions.

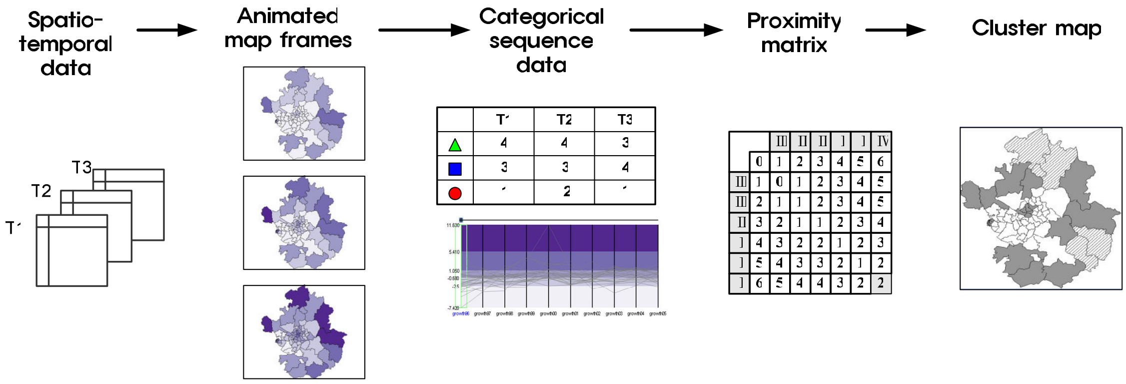


Figure 1. Analysis process of animated map frames

### 1. Generating frames for map animation

Frames of animated map are generated by applying choropleth classification to spatial attributes at each time. The classification scheme should be constant over all time frames to assure consistency of classification results over time.

### 2. Temporal sequence construction

With this series of choropleth maps, change of each sub-region can be represented by a sequence of class membership status. Figure 2 illustrates the class membership sequence of each sub-region in temporal coordinate plot. Each trajectory in the plot represents how the class membership of each sub-region has changed over the entire time period.

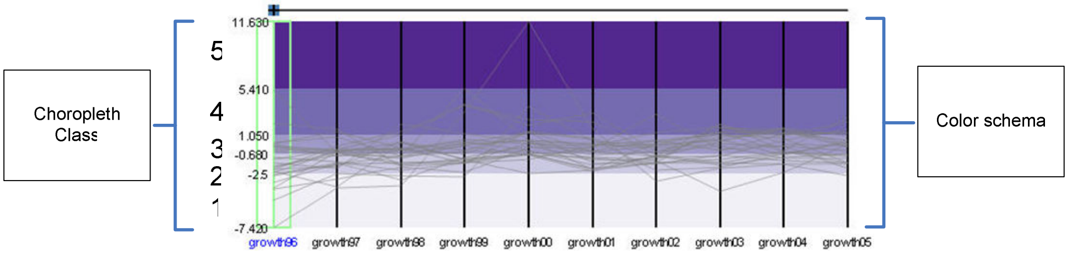
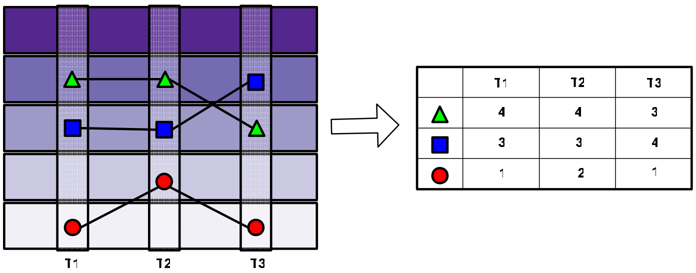


Figure 2. Temporal class membership change over time in parallel coordinate plot

Figure 3 illustrates how temporal sequences are constructed choropleth map frames. For example, a sub-region with blue square have class memberships changing [3, 3, 4] over time [T1, T2, T3].



| | T1 | T2 | T3 |
|---|---|---|---|
| ▲ | 4 | 4 | 3 |
| ■ | 3 | 3 | 4 |
| ● | 1 | 2 | 1 |

Figure 3. Temporal sequence construction

## 3. Cluster analysis

Temporal sequences of class membership of sub-regions can be compared to each other to explore and analyze spatial and temporal pattern in the geographic phenomenon. For example, any group of sub-regions that have similar temporal pattern of change can be identified by cluster analysis using proximity measures between sequence data. In order to calculate similarity measures for membership sequences, we employ Levenshtein metric (Levenshtein 1966), which is a type of string edit methods. Levenshtein metric is one of the most widely used methods for sequence comparison of categorical data for its computational simplicity and efficiency. Levenshtein metric is defined as the minimum number of edit operation (insertion/deletion/substitution) needed to transform one sequence into the other, namely, a unit cost for the edit operations. Suppose there are two sequences of nominal variable, simple two strings like ‘KITTEN’ and ‘SITTING’. To make ‘KITTEN’ same as ‘SITTING’, 1) we need to substitute K with S; 2) substitute E with I; and 3) insert G at the end. Dissimilarity between those sequences is calculated by how many steps we have (in this case, 3).

Based on the proximity matrix calculated by Levenshtein metric, temporally changing pattern of sub-regions can be compared to each other, and clustered regions of common temporal pattern can be identified by various clustering algorithms as show in Figure 5. In such way, a unique pattern in each cluster can be identified interpreted spatially and temporally at the same time. Example in Figure 6 illustrates that a certain group of sub-regions centered by Seoul metro area have similar pattern of land price fluctuation, and temporal pattern of the change can be explored by accompanying parallel coordinate plot.

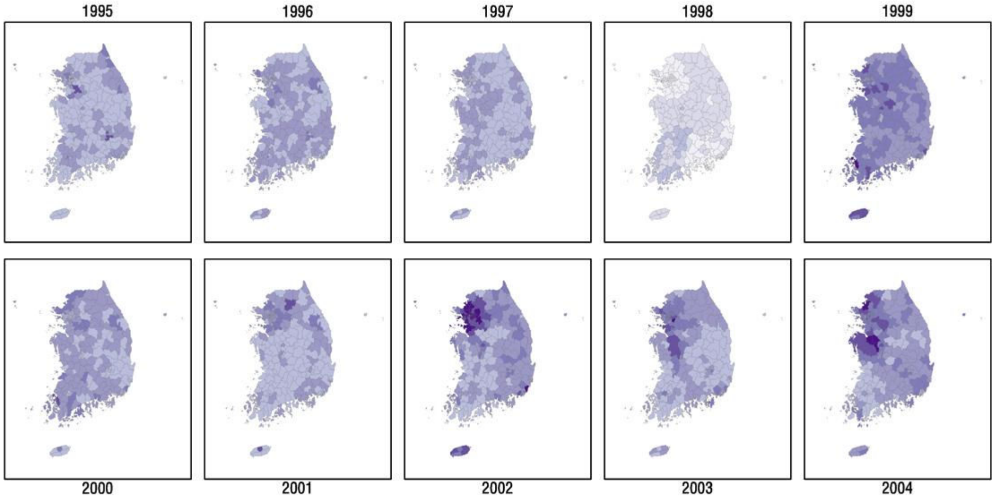


Figure 1 animated map frames

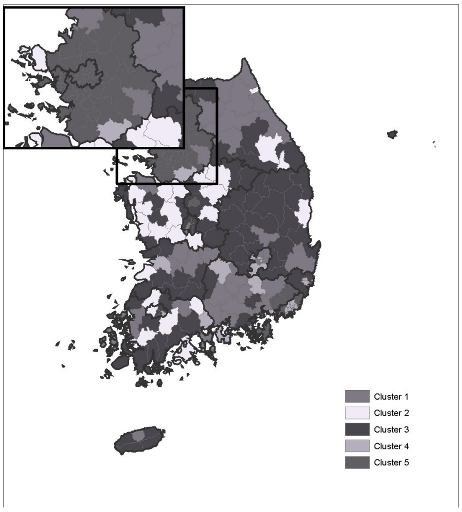


Figure 2 Cluster map

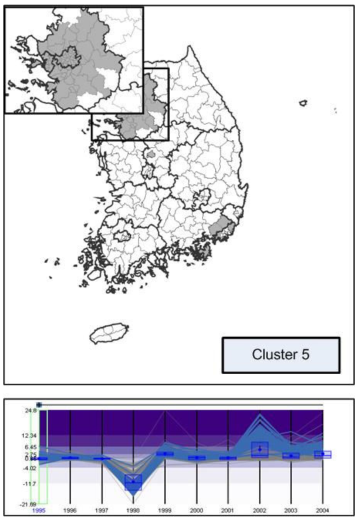


Figure 3 Cluster 5 and its temporal parallel coordinate plot appearance

## Concluding remark

Animated map by itself is sometimes treated as just a fancy presentation of spatio-temporal dynamics of geographic phenomenon. However, when combined with various computational methods in context of geovisual analytics, it has a huge potential for exploratory data analysis of spatio-temporal datasets. This study proposes a way to extend functionality of animated maps by integrating visualization and computational methods such as modified temporal parallel coordinate plot, sequence analysis using Levenshtein metric.

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