CO-264

EFFECTIVENESS OF VISUAL, SCREEN AND DYNAMIC VARIABLES IN ANIMATED MAPPING

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ABSTRACT

Along with the development of computer science and the revolution of Internet, animated maps are more and more needed to represent the spatial-temporal data by animated mapping effectively and appropriately. To meet the increasing requirements for dynamic representation and to provide supports for spatial-temporal data visualization, it is necessary to study which and how different variables affect map animation and to evaluate the effectiveness of variables for presentations in animated mapping. This study proposed a research framework aims to evaluate the effectiveness of variables for presentations in animated maps. Some quantitative approaches have been developed to achieve this goal. The efficiency and validity of various variables were compared for the same animation map. To be specific, three types of variables were considered. They are visual variables, screen variables and dynamic variables. And a preliminary result is showed in this paper.

KEYWORDS

animated map, geographic visualization, visual variables.

BACKGROUND AND OBJECTIVES

With the development of computer science and the revolution of Internet, specific demands arising from cartographic science, important challenges to cartography will be related to mapping spatial data's multi-dimensional and temporal component. The traditional static maps, whether representing on paper or on screens, cannot satisfy the users' need any more. Animated maps are needed to represent the spatial-temporal data effectively and appropriately. Despite wide promotion of the benefits of animation, there is little empirical evidence demonstrating that animated representations are indeed superior to static small-multiple representations of processed (Griffin et al. 2006). There are different result for studied of static small-multiple and animated cartographic representations. Kossoulakou and Kraak (1992) found that there is no different in accuracy of the subjects' answers between the two types of maps, but giving the answer more quickly when they use animated representation. In contrast, Cutler's (1998) study indicates that static small-multiple maps are more effective than animated maps. In a recent qualitative evaluation by Slocum et al. (2004), the result tell us that different type of maps were best used for completing different tasks: animations for identifying general trends and static small-multiples for comparing specific time points. Therefore, more studies are needed to explore the effectiveness of animated maps and more experiments should be done to qualitatively evaluate the representation efficiency of animated maps. This report is motivated by an urgent need of developing guidelines for creating animated maps and evaluating the effectiveness of variables for presentations in animated maps.

APPROACH AND METHODS

To compare animated maps with different visual variables, dynamic variables and screen variables, we will use a within-subjects experimental design in which each participant saw each animated maps in different variables conditions.

In the experiment, our goal is to compare the representation effectiveness of animated maps with different visual, dynamic and screen variables conditions. To make the experiment practical, we have to control for many factors. Pilot studies and observations about use of the many different map animations let us focus on few selected factors. These factors are (a) color hue, color saturation, color value, texture and size which are visual variables; (b) duration, rate of change and order which are dynamic variables; and (c) contrast, resolution and transparency which are screen variables. As a result, we design the experiment to test for these variables while controlling for others.

In order to minimize the practice effects in the experiment, a balanced Latin Square design will be used within the test for each condition. In a balanced Latin Square design, each condition precedes and follows each other treatment equally often, and each condition appears in each ordinal position the number of time.

We hypothesize that the most effective variables are detected faster and have more accuracy of the responses than less effective ones. Therefore, the test instruments collect two pieces of data for each trial that each subject completed in the first section of the experiment: the answer he or she recorded and the

time he or she took to answer. After that, the subjects will be request to finish a small questionnaire which collecting the basic information of the subjects.

Participants

The participants selected for these experiments should have a low to average training in geographic information science, such as cartography, geographical information systems, including the general familiarity with and usage of spatial data. And the participants tool should have a low or average level of training in computer science and related fields. So we choose the participants from the freshmen of the undergraduate students, who are mostly between the ages of eighteen and twenty-four years of age, and who were from varied academic backgrounds. Further, the number of males and females are balanced.

Materials

The H.K. digital map of main road, and the traffic flow data of Hong Kong in 2008 gathered from "The Annual Traffic Census 2008" which was published by Transport Department of HKSAR Government, and the traffic accident data of Hong Kong in 2009 which was get from Transport Department of HKSAR Government will be used in this study as basic data to produce animated maps. All the animated maps will be produced using the software of ArcGIS 9.3, Adobe Photoshop CS3 and Adobe Flash CS3. And the computer program used in the experiment will be developed by Microsoft .Net with the coding language of C#.

Experimental procedures

This experiment was a preliminary trail for the research and it attempted to evaluate the effectiveness of the visual variable of color saturation. The animated maps were based on the traffic flow data of Hong Kong main road in 2008. There are three sections in the experiment.

In the first section of the experiment, the subjects were request to find five busiest sections of the road network of the whole day by their personal feels and recorded their answers in the computer programs. In the experiment the subject would see the computer screen, and the similar picture of Figure 1 would be displayed on the screen in each section of the experiment. The left part of the screen displayed the original animated map which let the subjects to interpret the represented information, and the right part of the screen displayed static map of the corresponding road network of the animated map in the left part of the screen. The static road network map was for the subjects to record their answers, Figure 2 illustrated how the answers being recorded. In each part of this section, the answer of the subjects recorded and the time he or she took to answer were recorded by the computer programs.

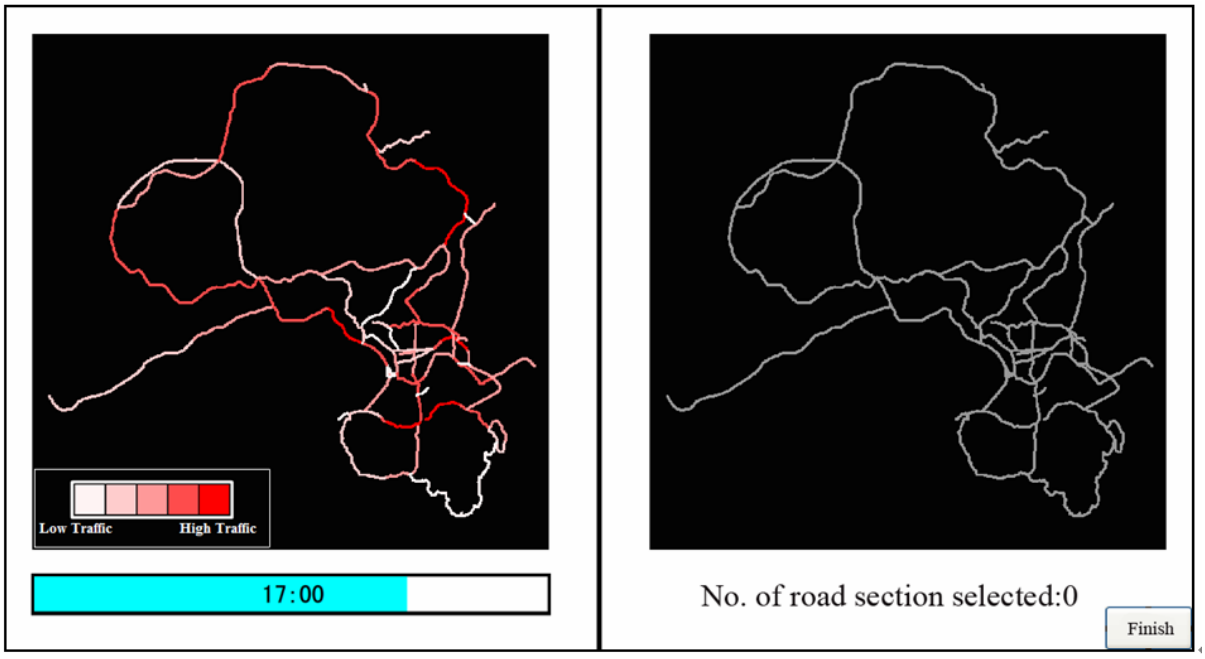

Figure 1: The contents what the screen displayed in the first section of the experiment.

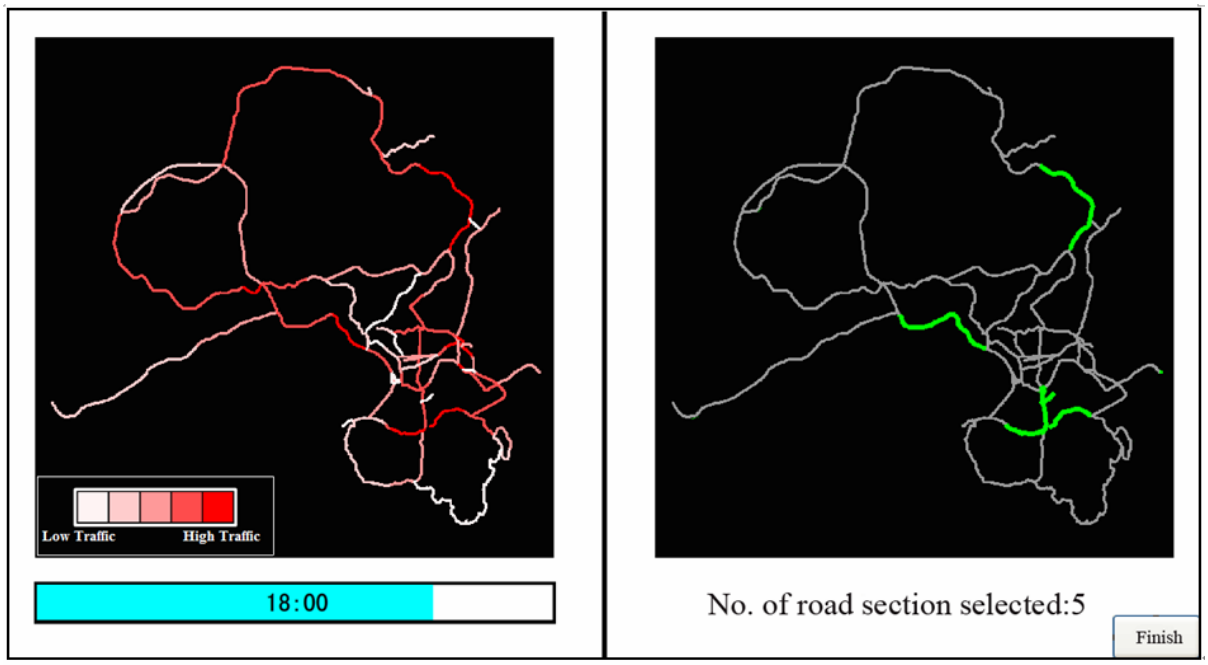

Figure 2: The contents what the screen displayed in the first section of the experiment.

In the second section of the experiment, the subjects were request to see the six animated maps at the same, Figure 3 illustrated the contents displayed on the screen of this section. And the answers of the subjects given were recorded.

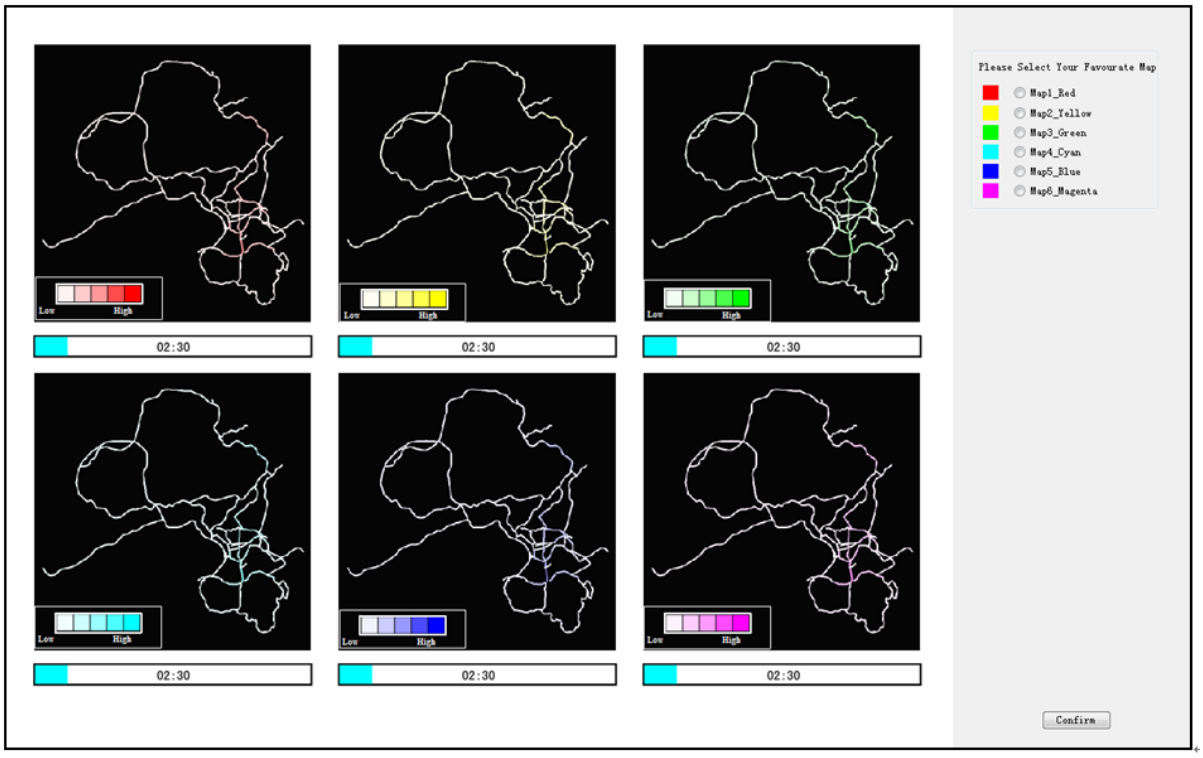

Figure 3: The contents what the screen displayed in the second section of the experiment.

In the third section of the experiment, a demographic questionnaire should be filled out by the subjects, where they indicated their age, gender, field of study, preference of colors, and the familiarization of map use and so on.

RESULTS

Descriptive Statistic

Table 1 and Table 2 are the descriptive statistic data of the response time and the accuracy of the answers, which includes mean, median, SD and so on.

Table 1： Descriptive statistic of response time of answers

Response Time

Map Type	Mean	Median	Harmonic Mean	Geometric Mean	Std. Deviation	Skewness
Blue Map	44126.09	38296.00	30599.07	36851.48	28678.872	2.144
Cyan Map	46690.02	39406.00	34738.52	40410.69	24824.475	.686
Green Map	47334.74	43156.00	30894.63	38687.59	29239.023	.873
Magenta Map	46344.79	39234.00	31167.71	37955.15	31637.518	1.859
Red Map	48141.51	37687.00	31938.77	39057.80	33376.045	1.388
Yellow Map	50180.16	40343.00	35598.75	41922.11	35041.644	2.383

Table 2： Descriptive statistic of the accuracy of answers

Accuracy

Map_Type	Mean	Median	Harmonic Mean	Geometric Mean	Std. Deviation	Skewness
Blue_Map	.691813	.600000	.619565	.661373	.1851941	-.376
Cyan_Map	.712281	.800000	.627523	.676109	.2036017	-.488
Green_Map	.752047	.800000	.681275	.721672	.1930352	-.597
Magenta_Map	.720468	.800000	.640449	.683812	.2161858	-.185
Red_Map	.769591	.800000	.720001	.745948	.1834716	-.254
Yellow_Map	.721637	.800000	.a	.000000	.2430373	-.661

a. The data contains both negative and positive values, and possibly zero values.

Because the absolute value of skewness is large in Table 1, we use the median, which is primarily used for skewed distributions, to make the comparison of different animated maps. Figure 4 is the boxplot that illustrates the time taken to complete the task in each animated map.

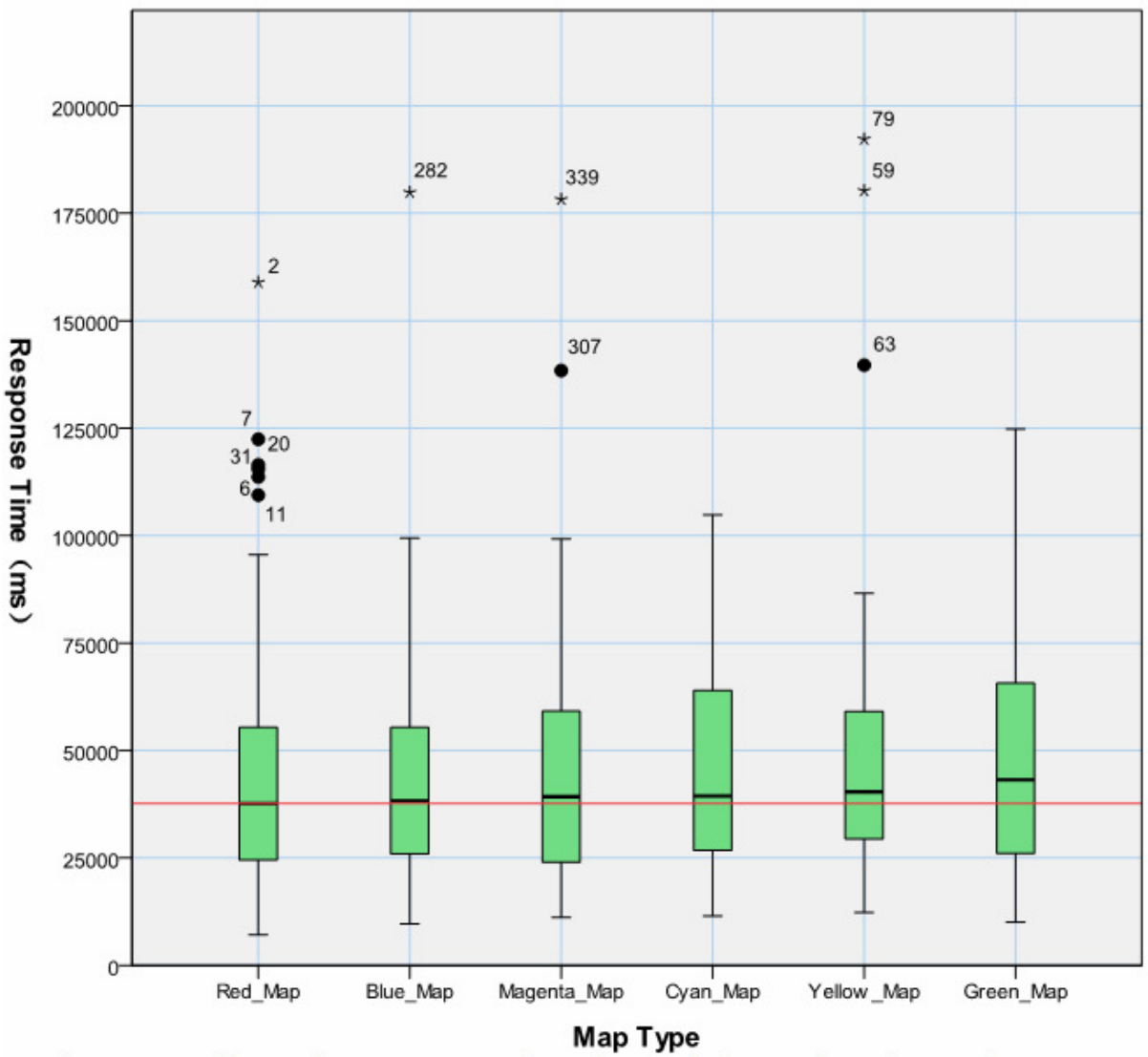

Figure 4: Time taken to complete the task in each animated map.

From the figure 4 we can see that the median of time taken to complete the task in each animated map is different but the difference is not large. The ranking of the animated maps according to the response time from small to large is Red Map, Blue Map, Magenta Map, Cyan Map, Yellow Map and Green Map. Based on the theory mentioned before, the less time used to complete the map reading task, the more effective the map is. We can say that the most effective animated map is Red Map, and the second effective animated map is Blue Map, and then followed with Magenta Map, Cyan Map, Yellow Map and Green Map.

Figure 5 is the histogram that illustrates the percentage of road section correctly selected in each animated map.

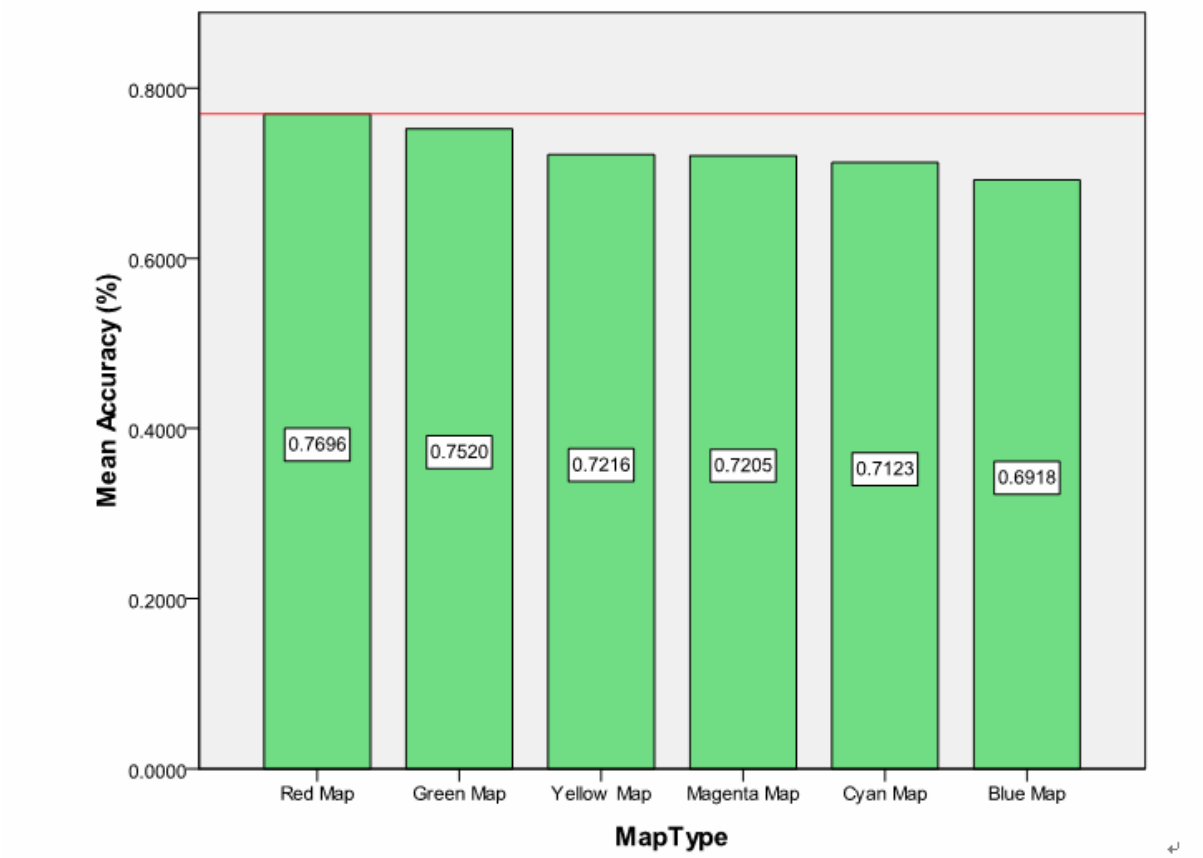

Figure 5: Percentage of road section correctly selected in each animated map.

From the figure 5 we can see that the average of the percentage of road section correctly selected in each animated map is different but the difference is not large. The ranking of the animated maps according to the mean accuracy from large to small is Red Map, Green Map, Yellow Map, Magenta Map, Cyan Map and Blue Map. Based on the theory mentioned before, the more accuracy of the response, the more effective the map is. We can say that the most effective animated map is Red Map, and the second effective animated map is Green Map, and then followed with Yellow Map, Magenta Map, Cyan Map and Blue Map.

Considering either the time of response or the accuracy of the response, Red Map is the most effective one and the effectiveness of other maps is not clear. Figure 6 illustrates clearly that Red Map has the most accuracy of response and the least time of response.

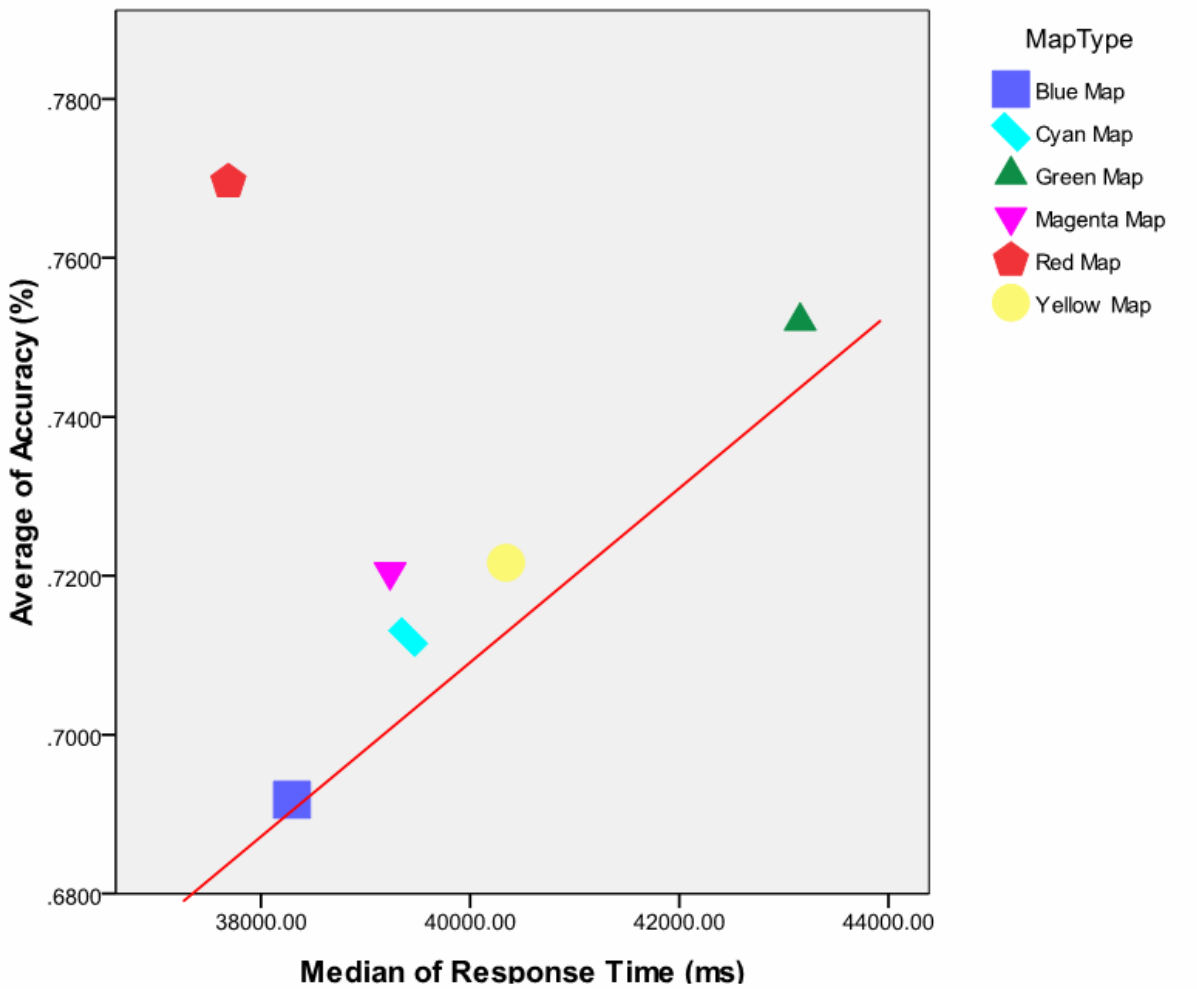

Figure 6: Average of accuracy and median of response time of each animated map.

We can deduce that the color red is the most effective hue to represent the traffic flow data in animated representation, but it is not clear of other hues based on the data analysis of descriptive statistic.

Analytic Hierarchy Process (AHP)

Constructing the AHP hierarchy for choosing the most effectiveness animated map is the first step for this analysis. The goal here is "Choose the Most Effective Animated Map (A)", and there are three criteria for choosing the map: Response Time (B1), Accuracy of Answers (B2), Personal Choice (B3) (the subjects were request to see the six animated maps at the same and choose one as their most favorite one in the second section of the experiment), and there are six candidates maps (C1-C6), See Figure 7.

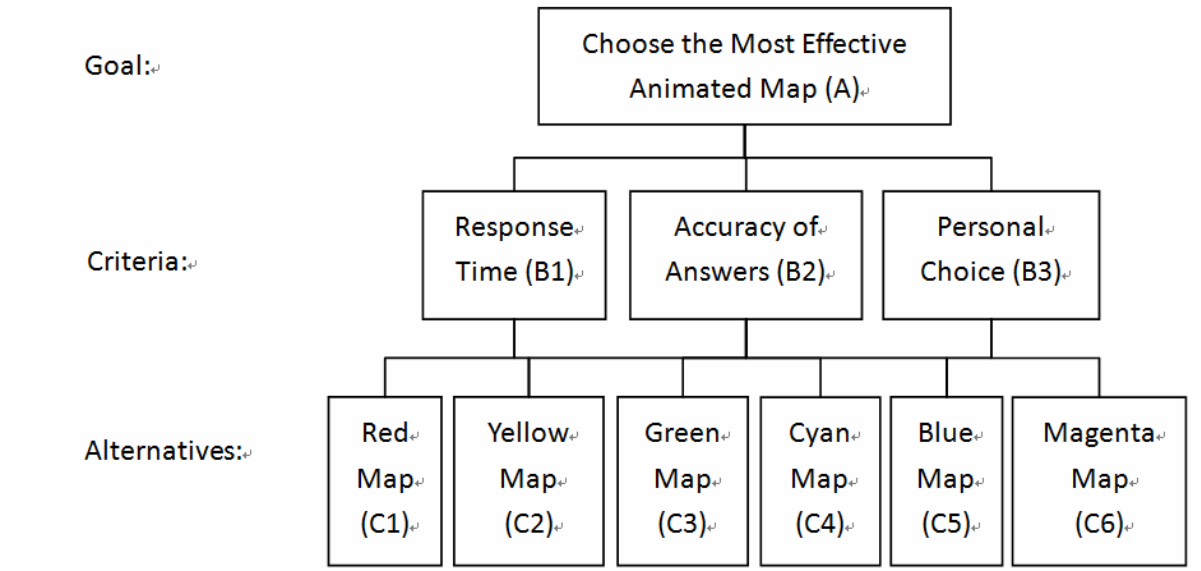

Figure 7: AHP hierarchies for choosing the most effectiveness animated map. There is one goal, six candidates and three criteria for choosing among them.

We compute the overall composite weight of each alternative choice based on the weight of two levels, Table 3 shows the result.

Table 3 overall composite weights of the alternatives

	Response Time (B1)	Accuracy of Answers (B2)	Personal Choice (B3)	Composite Weight
Weight	0.6434	0.2828	0.0738	
Red Map (C1)	33.38%	47.25%	23.23%	36.55%
Yellow Map (C2)	7.40%	9.05%	3.31%	7.56%
Green Map (C3)	2.47%	25.97%	9.14%	9.61%
Cyan Map (C4)	16.20%	5.73%	4.56%	12.38%
Blue Map (C5)	26.67%	2.94%	50.18%	21.69%
Magenta Map (C6)	13.88%	9.05%	9.58%	12.20%

From Table 3, we get the results that Red Map is the most effective one, followed by Blue Map as the second one and the Yellow Map is the worst one. Figure 8 is the histogram of the AHP result.

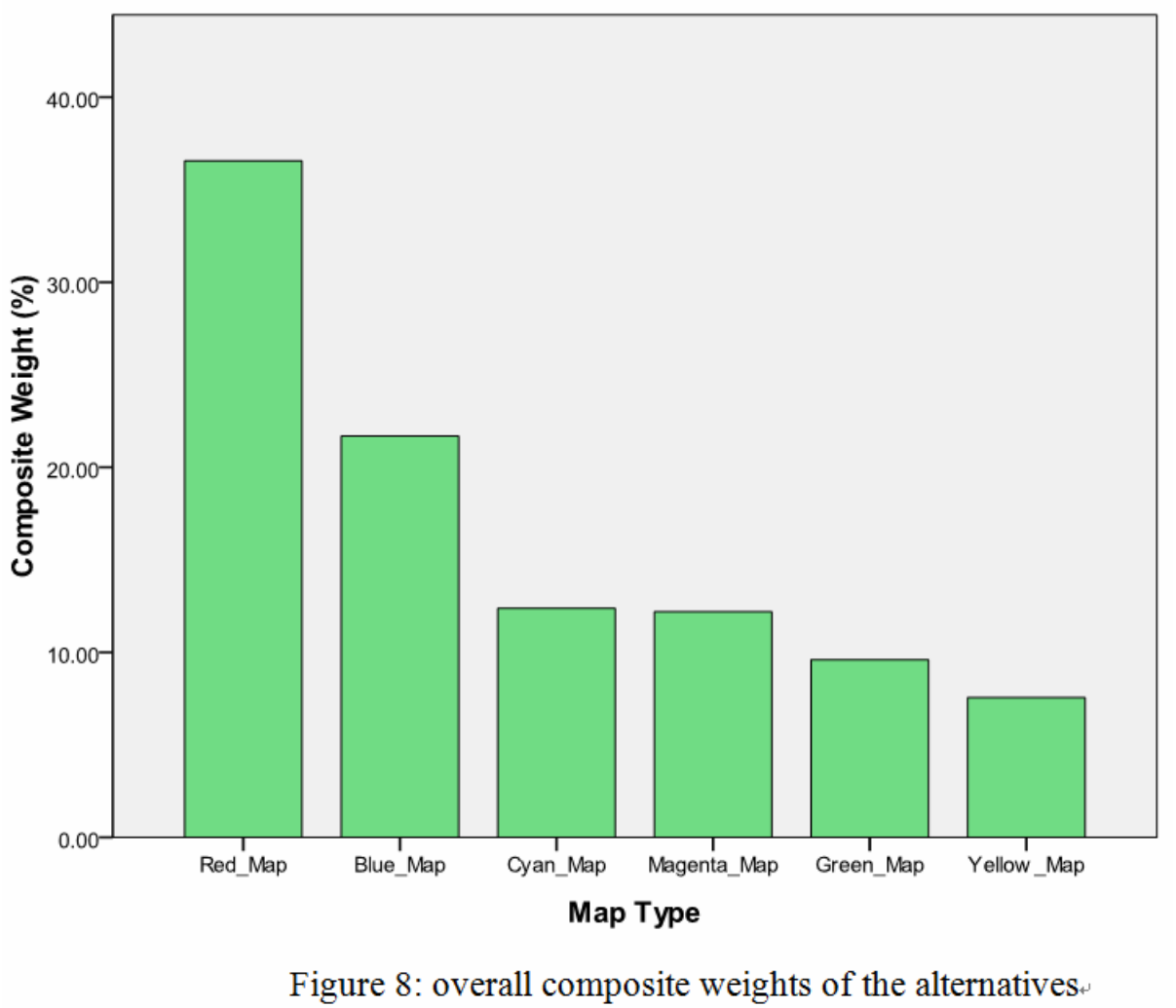

Figure 8: overall composite weights of the alternatives

We can conclude that red is the most effective color hue to represent the traffic flow data by change the value of saturation in animated representation, and followed with the color hue of blue, cyan and magenta. And the color hue of yellow and green are the worst two hues to represent the traffic flow data in animated representations.

CONCLUSIONS AND FUTURES PLANS

In this report, some preliminary results of evaluating the effectiveness of visual variables were given out. However, further analyses are still needed to get more significant conclusions. Also more variables are needed to evaluate its effectiveness. In addition, most of my time in the future will focus on implement of assessing the other variables like visual variables, dynamic variables and screen variables in my designed framework.

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