Multivariate Visualization of Continuous Datasets, a User Study

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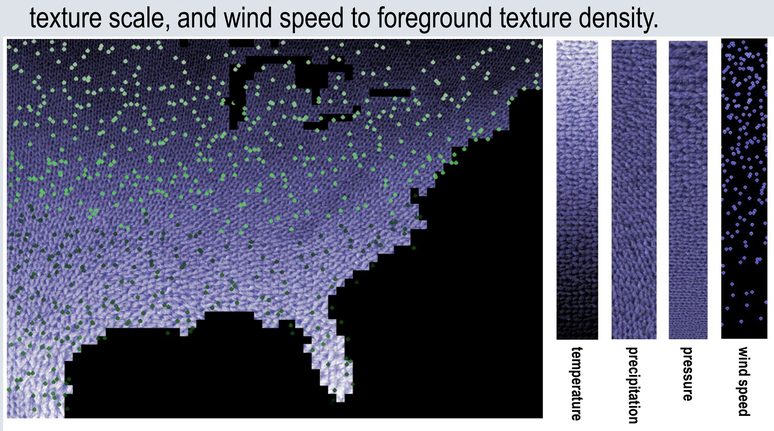
Introduction

Visual analysis in areas such as fluid flow, meteorology, geology, and astronomy commonly require domain experts to make decisions based on relationships between several continuous or segmented variables. One of the primary goals of multivariate visualization is effectively presenting overlapping layers of data. Poor representations can produce unintended visual interactions and visual artifacts that mislead observers into perceiving correlations or relationships that do not exist in the original data.

This poster presents the experimental design of an ongoing study aimed at evaluating the effectiveness of three multivariate visualization techniques: multi-layer controlled texture synthesis using natural textures [5], perceptually-based brush strokes for non-photorealistic visualization [2], and side by side colors [1] [4].

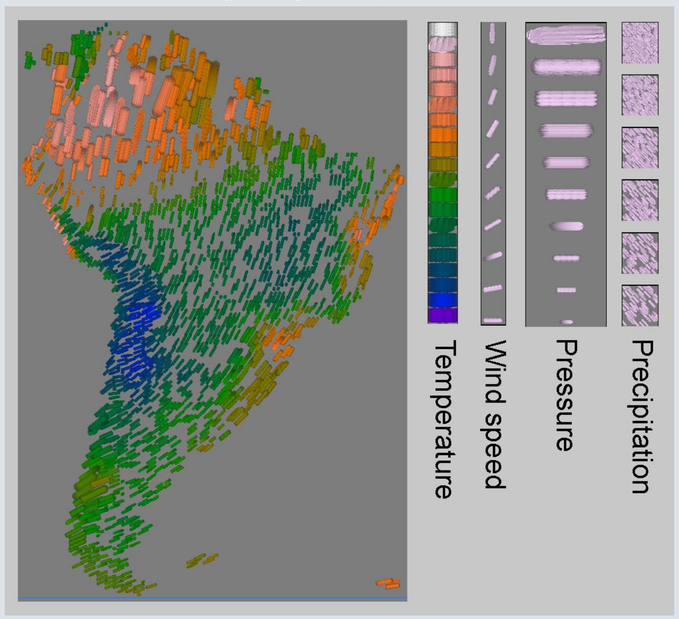
Method 1: Natural Textures for Weather Data Visualization

This method visualizes multiple data attributes using a controllable multi-layer texture synthesis. In the example below, temperature is mapped to brightness, precipitation to texture orientation, pressure to texture scale, and wind speed to foreground texture density.



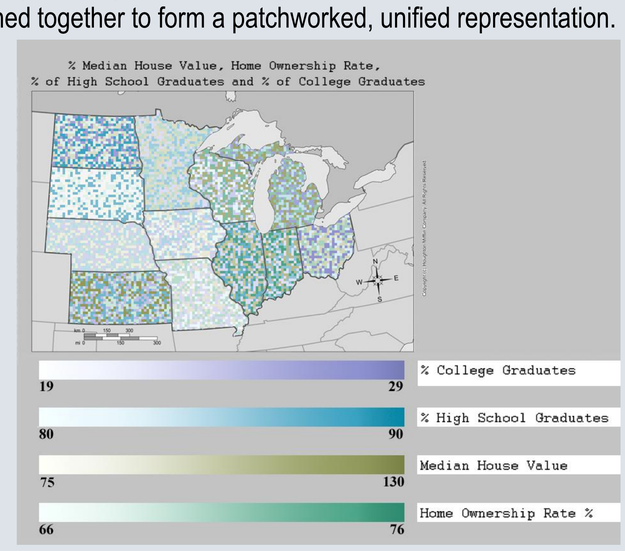
Method 2: Perceptually-Based Brush Strokes for Nonphotorealistic Visualization

This method draws from Impressionist painting techniques and human visual perception to generate perceptually salient painterly visualizations. Visual attributes of brush-stroke glyphs are varied to represent the data. In the example below, temperature, wind speed, pressure, and precipitation are mapped to brush stroke color, size, orientation, and coverage, respectively.



Method 3: Side by Side Colors for Multivariate Visualization

In attribute blocks the individual colors of multiple variables are separately woven to form a fine-grained texture pattern. In the following example, the separate color layers are individually sampled at independent pixels defined by a random noise function and then stitched together to form a patchworked, unified representation.



User Study Goals and Hypotheses

MacEachran and Kraak presents four general conceptual level goals for geographic visualization: exploration, analysis, synthesis, and presentation. The emphasis of this research is on information exploration [3].

We aim to provide insights into the effectiveness of each of the three approaches included in the study for performing a series of common analytic tasks that occur during information exploration on maps.

The context specific goal of this research is to facilitate exploration of spatially varying factors in climate change datasets. To achieve this goal, we wish to measure how well naïve observers are able to perform the following tasks:

- Read and understand the basic information presented in the map
- Recognize possible patterns for each variable
- Recognize relationships in the integrated variables and draw conclusions from such relationships

We believe that:

- In methods 1 and 2, certain visual features may be more salient than others, whereas method 3 provides equally salient representation for all attributes.
- Some methods may consistently facilitate type 1 tasks better than type 2 tasks and vice versa.

User Study Tasks

Type 1 :

- Identify the maximum value for each variable inside the blue box, by clicking on the bin which best matches the maximum observed values.

Type 2:

- Is there a positive (or any) correlation between two variables? [yes, no]
- When variable “a” goes from low to high what is the behavior of variable “b”? [no clear relationship, goes from low to high, goes from high to low]
- Is there a cluster in which the values of “c” are constant while the values of both “a” and “b” increase? [yes, no]
- Is the value of “a” generally (over 80%) greater than the value of “b”? [yes, no]

User Study Method

Dataset: the Climatic Research Unit global climate dataset, consisting of a multivariate 0.5° latitude by 0.5° longitude resolution monthly averages of eleven weather conditions collected for positive elevations throughout the world from 1961 to 1990 and averaged over these 30 years by the Intergovernmental Panel on Climate Change [5].

Data variables visualized: mean temperature, precipitation, vapor pressure, and wind speed

Map dimension: 122 x 61, scaled by factor of 10

Tasks:

- type 1: basic map reading task for each variable
- type 2: inferring correlation between variables

Experiment design: within subject

Dependent variables:

- time taken to complete task
- amount of error (between ground truth and observer’s answer)

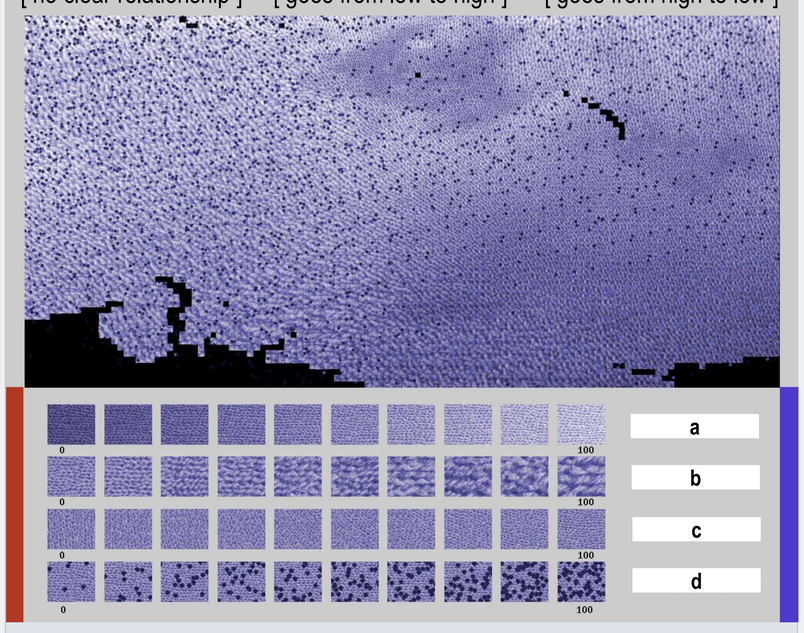
Independent variables:

- visualization method
- data variables
- participant
- tasks

User Study Example Stimuli

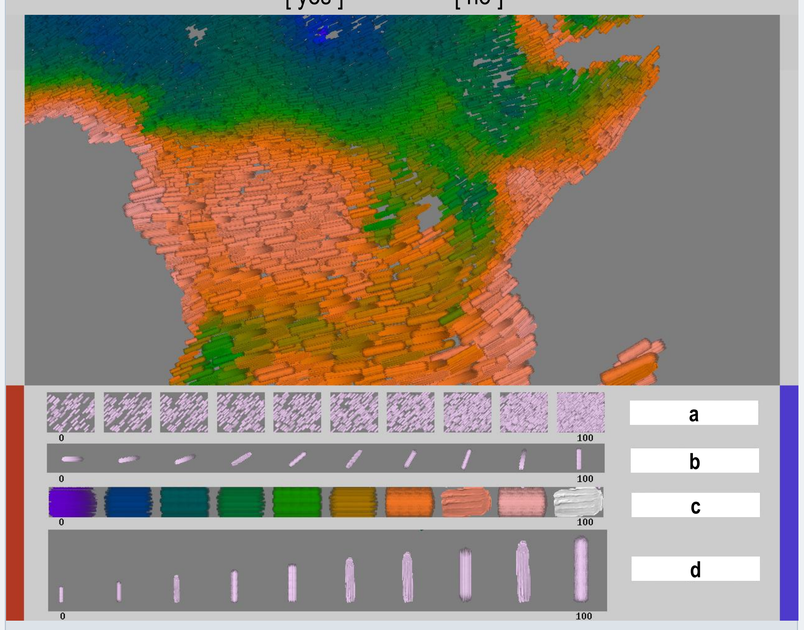
Where “b” goes from low to high, what is the behavior of “d”?

[no clear relationship] [goes from low to high] [goes from high to low]

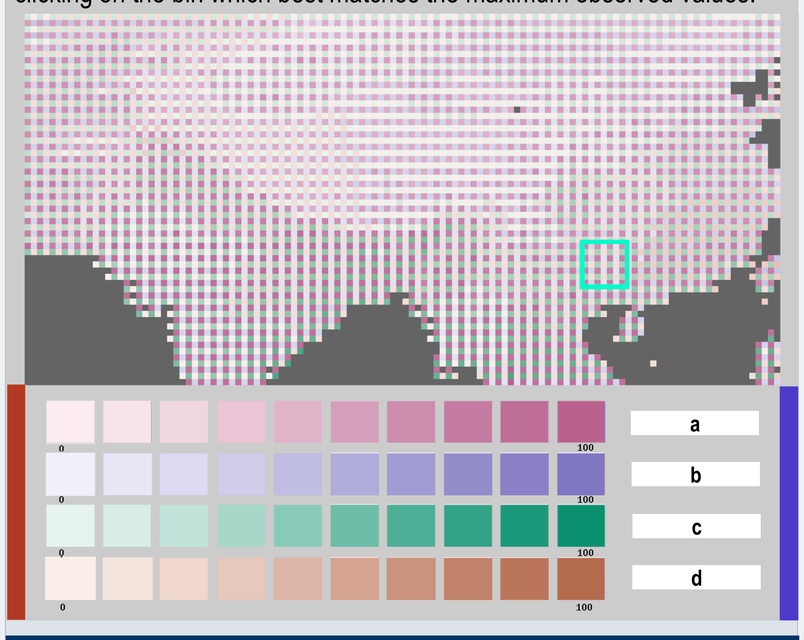


Is the value of “a” generally (over 80%) greater than the value of “b”?

[yes] [no]



Identify the maximum value for each variable inside the blue box by clicking on the bin which best matches the maximum observed values.



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