Poster: Scattering and Jittering: Using Real and Illusionary Motion for Better Visual Scatterplot Analysis

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Abstract

A scatterplot is one of the most popular techniques used for visualizing multidimensional datasets. However, if the number of data points is large, occlusion and overdraw problems occur. Thus, it will be difficult to visually differentiate these data points and their clusters. Motion is one of the strongest low-level perceptual cues to draw our visual system's attention to a certain subset of data. In this paper, we present three approaches that use different motion concepts to improve the identification and separation of precomputed clusters in scatterplots. First, we present two techniques generating real motion effects by the use of flickering and by the use of different weaving patterns. Furthermore, we present a technique using mimic motion by the use of peripheral drift.

Keywords: Information visualization, scatterplot displays, motion encoding.

Index Terms: H.5 [Information Interfaces and Presentation]: General; H.5.2 [Information Interfaces and Presentation]: User Interfaces—Screen design

1 Introduction

Many approaches aim at reducing visual clutter to enhance the interpretation of at least partially dense scatterplots. Kosara et al. provide an overview of the various Focus+Context techniques, such as methods for distortions, overview, semantic depth of fields, etc. To enable the early detection of specific characteristics of the display and to facilitate the differentiation of different characteristics, perception research should be considered. An overview of perceptual methods for visualization is provided by the survey paper of Bartz et al. [3]. Using motion as one of the strongest low-level perceptual cues, our approach is an attempt to draw our visual system's attention to a certain subset of data.

Mapping high-dimensional data onto two display dimensions requires preserving the characteristics of the given dataset. In the case of classified data, this means in particular that the class structure has to be communicated by the 2D view. However, if too much data is displayed on too small areas, visual clutter occurs leading to a loss of information, and specifically to a visual merging of clusters. Several metrics and measures were introduced to identify and solve this problem.

Motion as a perceptually salient visual cue has been used quite often in visualization to highlight information. In particular for time varying flow fields, motion has been exploited to show flow patterns in more abstract [5] or more LIC-like representations [8]. For the visualization of non-spatial data (aka information visualization), however, it has been used in a surprisingly limited fashion.

For the use of motion as an interaction tool several different approaches were proposed (e.g.,[1]). More closely related to our approaches, however, is the use of motion as a mapping technique which in our opinion, has not yet to been sufficiently exploited in the field of multidimensional visualization. In perceptional research particular motion concepts have been investigated quiet intensively and were briefly reviewed by Huber and Healey in [4]. They decribe the effectiveness of flickering, directed motion, and motion velocity to encode multifield datasets. Similarly, Ware and Bobrow examined oscillating motion to highlight nodes in large graphs and compared them to static highlighting methods [9]. The use of motion to group elements is closely related to our goal of improving the identification and separation of precomputed clusters in scatterplots. Specifically, linear motion and horizontal and vertical oscillation enable the identification of visual groups, if the motion is coherent in the group.

A current theory on peripheral motion illusions based this illusion on fast and slow changes of contrast or luminance over time in the neuronal representation [2]. Several empirical studies analyzed the occurrence of peripheral motion perception and quantified luminance values to enhance the strength and speed of motion [6]. Furthermore, Gregory and Head investigated how different luminance and shape patterns influence the recognition of motion.

In this paper, we use motion as a perceptually salient visual cue for identifying dense regions with cluster merging and for separating those clusters in scatterplots. We achieve cluster identification and separation by modifying different attributes guided by insights from perception research. While this can be typically also achieved using "traditional" visual cues such as color, we will show that motion works at least as good as or better than color. In contrast to animated scatterplot representations such as Grand Tour [1], the overall orientation of the scatterplot is not changed, thus keeping the orientation fixed.

2 Motion Techniques

In this paper, we use three different kinds of motion to support the identification and the separation of multiple clusters in a high-dimensional dataset. First, we present two techniques generating real motion effects by the use of flickering and of different weaving patterns. Furthermore, we present a technique using mimic motion by the use of peripheral drift. The three techniques are presented regarding the motion effect they generate. The jittering moves objects by translation of data points. The alternating weaving patterns only change one attribute of the weaving technique and presents alternatively different weaving patterns. The peripheral drift exploits the visual recognition to initialize a mimic motion with a static image. Beneficially, the alternating weaving patterns and the mimic motion are position preserving motion techniques.

2.1 Flicker of Data Points

In this case, all data points of a given cluster are displaced by a small offset in randomly chosen directions. This displacement results in a coherent oscillation around the data point's original position in the scatterplot. To emphasize an area, and hence a specific cluster a sufficiently high frequency of the motion is required. In our setup, we use a frequency of 17 Hz or higher, resulting in a cycle length of 60 milliseconds (or less). For the scale of the linear motion, a fraction of the data point's size of about 20% is sufficient to obtain

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the desired effect. The extent of displacement can be individually adjusted by the user. However, the minimum flicker differences reported by Huber and Healey should be taken into account to provide a good separability of the different clusters.

2.2 Alternation of Weaving Patterns

With the Weaving technique ([7]) the colors of overlapping objects are not combined, as in blending, but are arranged column- or row-wise. Hence, the visibility of single objects in overlapping regions can be supported. We have applied this weaving technique to improve the recognition of overlapping clusters in scatterplots. For this purpose, different weaving patterns (each communicates the shape of a specific cluster) are alternatively presented (see Figure 1). In that way, a movement can be displayed without moving any object, but only changing a single parameter in the weaving technique. Hence, this technique preserves the position of the data points.

2.3 Mimic Motion using the Peripheral Drift

The illusive motion using the peripheral drift exploits a perceptual effect of the human visual system (HVS), in particular of the peripheral visual field. Our HVS recognizes bright objects (points in our case) first, and interprets dark objects thereafter. For an object composed of bright and dark contours, combined with a low peripheral resolution, the resulting delay leads to a peripheral, illusive motion (peripheral drift). The HVS is conditioned to consider one light source (sun). Hence, if objects with inverse bright and dark contour and a specific background occur, a misinterpretation takes place which is compensated by a mimic motion. To realize the mimic motion for the scatterplot, we follow the setup suggested by Backus et al. [2], where the one contour uses black (0% luminance), the object itself colored with dark gray (40% luminance), the opposite contour uses white (100% luminance), and the background is set to light gray (80% luminance) (see Figure 1). Note that this effect only occurs if parts of the picture cover the peripheral visual field.

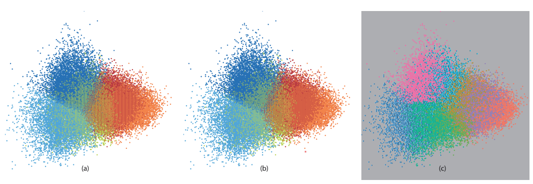

Figure 1: Picture (a) and (b) show different weaving templates, (c) depicts a scatterplot with applied mimic motion at two clusters.

3 Discussion

In common, all of the presented techniques use motion as visual attribute to support the perception of clusters in scatterplots. They differ in the number and way of modified attributes. In order to get a hint of the usability of our movement techniques we performed separate user studies. Therefore, a climate dataset of about 110 years, containing 40419 data points was used to generate two scatterplots in each case.

Flickering generates a motion by the translation of every data point of a cluster. Thus, a strong movement perception can be recognized by the user which supports a good recognition of the shape and spatial extension of a cluster. However, the positions of the data points are changed and it produces an additional cognitive load and hence, should be used carefully. In the user study we asked 23 participants, with experience in visualization, to count the number of clusters in two different scatterplots, one with 6 clusters (A) and one with 8 clusters (B). We divided the participants into two groups. Group 1 tested scatterplot A without movement and B with jittering, and Group 2 vice–versa. Thus, a learning effect could be prevented. The results show that the recognition of the number of cluster can be supported. With the application of jittering the number of correctly identified clusters in scatterplot A was increased by 17% and in scatterplot B by 73%.

For analyzing the number and shape of participating clusters in overlapping regions, the technique of Alternating Weaving Pattern is applied. Therefore, different weaving patterns emphasizing different clusters are shown successively. Beneficially, the positions of the data points are preserved, in spite of using movement. However, this technique also generates an additional cognitive load and should be used carefully. The usability of this weaving technique has been proven by a user study in [7] discovering the color and shape recognizability of the weaving technique in comparison to default techniques.

The mimic motion by using the peripheral drift does not change any positions. Furthermore, only a static image is required to generate the motion effect. Thus, this technique is also a position preserving technique. And it can also be used on static media, e.g. paper. However, using peripheral drift a maximum of four different movement directions can be generated. Furthermore, only 75% of the human population can perceive this effect. In the user study for mimic motion, 22 participants were asked to count the number of different clusters in two scatterplot setups. Two scatterplots were colored uniform gray containing three clusters (A). One of them had additionally applied mimic motion. The other two were colored with a different color for any cluster, containing eight clusters (B), also one with applied mimic motion. However, due to the characteristics of the mimic motion, it was applied only at the two clusters with similar colors. We also divided the participants into two groups, A and B with applied mimic motion were presented to the first group consisting of visualization novices and without mimic motion were presented to the second group consisting of visualization experts. In the first setup with only gray coloring, the number of correctly identified clusters could be increased by about 30%, with the applicationof mimic motion. In the second setup, with color coding, the success rate was increased by about 27%.

In conclusion of the user studies we suggest the following procedure: The mimic motion is used to enhance the recognition of the numbers of clusters. Furthermore, an improved recognition of the shapes of the clusters can be achieved by the use of alternating jittering. Eventually, the alternation of weaving patterns is used for perceiving the overlapping regions of different clusters.

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