Perceptually-Optimized Animations for Correlation Judgment and Visualization

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1 Introduction

Animation provides a unique opportunity to reinforce perceptual ideas pertaining correlation judgment. Yang suggests that people use "visual features" when judging correlations [6]. However, the aspects of perception considered here are purely static.

We are proposing an expansion of considered visual features to include animated visualizations as a potential method for perception. Mental translation has been found to be a factor for matching patterns between objects and would be a candidate for a visual task people perform [2]. Others tasks may include mental rotation or some other form of visual imagery.

Following similar methodologies of past experiments like Yang, such as Harrison et al [1], we will be testing to see whether the inclusion of these animation has an effect on participant performance. If animated feedback on the judgments differs from similar non-animated methods, our results will demonstrate that people may use some sort of visual translation or rotation task to process these comparisons.

2 One-sentence description

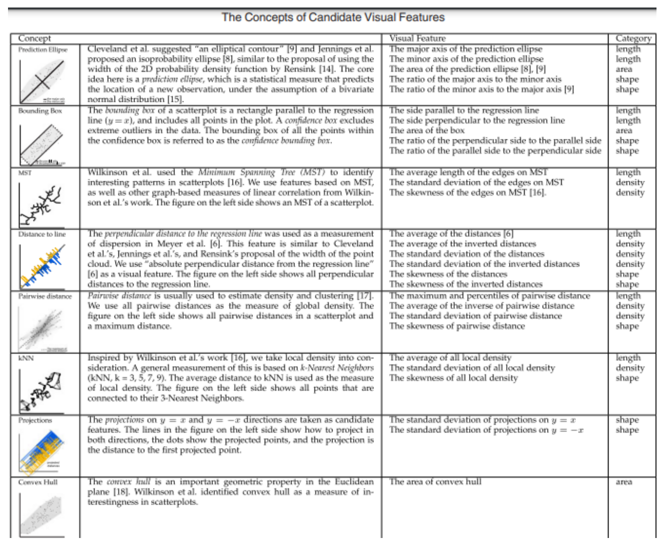
Expanding upon previous idea of correlation judgment, we are applying animation to determine if people utilize mental translation or rotation when judging correlation.

3 Project Type

Experiment (crowd-sourced)

4 Audience

Who is the audience for this project? How does it meet their needs? What happens if their needs remain unmet?



The Concepts of Candidate Visual Features

Concept		Visual Feature	Category
Prediction Ellipse	Cleveland et al. suggested "an elliptical contour" [9] and Jennings et al. proposed an isoprobability ellipse [8], similar to the proposal of using the width of the 2D probability density function by Rensink [14]. The core idea here is a *prediction ellipse*, which is a statistical measure that predicts the location of a new observation, under the assumption of a bivariate normal distribution [15].	The major axis of the prediction ellipse The minor axis of the prediction ellipse The area of the prediction ellipse [8], [9] The ratio of the major axis to the minor axis The ratio of the minor axis to the major axis [9]	length length area shape shape
Bounding Box	The *bounding box* of a scatterplot is a rectangle parallel to the regression line ($y = x$), and includes all points in the plot. A *confidence box* excludes extreme outliers in the data. The bounding box of all the points within the confidence box is referred to as the *confidence bounding box*.	The side parallel to the regression line The side perpendicular to the regression line The area of the box The ratio of the perpendicular side to the parallel side The ratio of the parallel side to the perpendicular side	length length area shape shape
MST	Wilkinson et al. used the *Minimum Spanning Tree (MST)* to identify interesting patterns in scatterplots [16]. We use features based on MST, as well as other graph-based measures of linear correlation from Wilkinson et al.'s work. The figure on the left side shows an MST of a scatterplot.	The average length of the edges on MST The standard deviation of the edges on MST The skewness of the edges on MST [16].	length density density
Distance to line	The *perpendicular distance to the regression line* was used as a measurement of dispersion in Meyer et al. [6]. This feature is similar to Cleveland et al.'s, Jennings et al.'s, and Rensink's proposal of the width of the point cloud. We use "absolute perpendicular distance from the regression line" [6] as a visual feature. The figure on the left side shows all perpendicular distances to the regression line.	The average of the distances [6] The average of the inverted distances The standard deviation of the distances The standard deviation of the inverted distances The skewness of the distances The skewness of the inverted distances	length density density density shape shape
Pairwise distance	*Pairwise distance* is usually used to estimate density and clustering [17]. We use all pairwise distances as the measure of global density. The figure on the left side shows all pairwise distances in a scatterplot and a maximum distance.	The maximum and percentiles of pairwise distance The average of the inverse of pairwise distance The standard deviation of pairwise distance The skewness of pairwise distance	length density density shape
kNN	Inspired by Wilkinson et al.'s work [16], we take local density into consideration. A general measurement of this is based on *k-Nearest Neighbors* (kNN, k = 3, 5, 7, 9). The average distance to kNN is used as the measure of local density. The figure on the left side shows all points that are connected to their 3-Nearest Neighbors.	The average of all local density The standard deviation of all local density The skewness of all local density	length density shape
Projections	The *projections* on $y = x$ and $y = -x$ directions are taken as candidate features. The lines in the figure on the left side show how to project in both directions, the dots show the projected points, and the projection is the distance to the first projected point.	The standard deviation of projections on $y = x$ The standard deviation of projections on $y = -x$	shape shape
Convex Hull	The *convex hull* is an important geometric property in the Euclidean plane [18]. Wilkinson et al. identified convex hull as a measure of interestingness in scatterplots.	The area of convex hull	area

Figure 1: List of conceptual visual features Yang theorized for how we perceive correlation in scatterplots.

Animation has been researched as a way to make presentations more interesting and engaging [5]. The core reasons why animation can be effective deserve exploring. Within correlation judgment, there are many opportunities to understand how people make these judgments with the work done by Yang [6]. Expanding this research to include animation can give a concrete basis for its usage within visualization of many kinds. If animation continues to be under-researched, it will remain a missed opportunity for many different areas of visualization.

5 Approach

Expanding of the above list of ideas used in Yang, we will add animation in the form of translation and/or rotation to most of these methods [6]. We will utilize

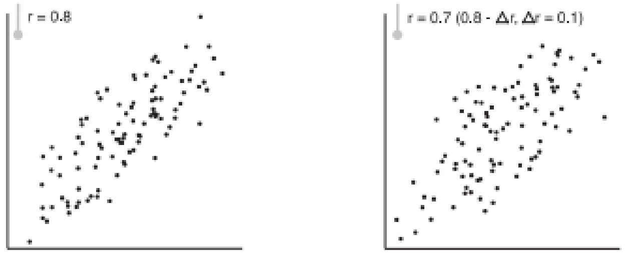


Fig. 2. An example of approaching a target correlation level from *below* in the experiments. Two side-by-side scatterplots (without any indication of actual correlation value or the regression line) are shown to the participant in the experiment. The participant chooses which of the two appears to be more correlated.

Figure 2: Methods used by Yang

the same method of evaluation as Yang to determine the specific animated features preform the best. The experiement method is outlined below. We will use this method in the way outlined by Yang in order to directly be able to compare our results

5.1 Evidence for Success

Why do you think it will work?

Based off the research done by Rensink [4] and Yang [6], there is a basis for evaluating judgment of correlation. Animation is just another dimension added on to this research that has the potential to capture other human perception ideas outlined in [2].

6 Best-case Impact Statement

In the best-case scenario, what would be the impact statement (conclusion statement) for this project?

In the best case, we will see similar results to Yang and Rensink. Additionally, we will see that animation as a feature has an effect on user performance. Ideally, this research will lay the groundwork for how animation effects human perception and give scientific basis for the inclusion of animation for a perceptual psychology standpoint. If this succeeds, further research can explore exactly which animations provide the optimal increase in understanding.

7 Major Milestones

- Replicate Yang's design
- Determine what additional feedback to include from the concepts: ellipse, box, KNN, etc
- Determine exact animations to use
- Pilot the design with all animations and feedback
- Full experiment to compare animation vs no animation (not in scope of class)

8 Obstacles

8.1 Major obstacles

- Some of the visual concepts are difficult/time consuming to replicate. To get a wide range of these will require great investment that may be out of scope.
- Most participants may not know to use the feedback. This feedback might not achieve anything if people don't already use some form of mental translation.

8.2 Minor obstacles

- Much of the design may have to be adapted from existing code/resources. Integrating many different experiments may cause issues.
- Getting a full experiment out takes finacial resources and additional time and thus might not be in scope for the project, but rather an entire research project on its own.

9 Resources Needed

What additional resources do you need to complete this project?

- Code and additional setup for the experiment
- Code and algorithms for the visual features
- Additional resources on perceptual psychology to inform the animation design
- Financial resources and additional time to complete a full experiment.

10 5 Related Publications

List 5 major publications that are most relevant to this project, and how they are related

- Yang provided the idea of visual features and a list of potential ones [6].

- Rensink created systems to evaluate the results of correlation judgment experiments [4].
- Robertson evaluated the current status of animation use in animation and provided alternatives and criticisms [5].
- Larsen developed methods to understand visual perception and mental translation [2].
- Li was able to compare performance for very different methods of visualizing correlation, which could be useful to apply between animated and static feedback [3].

11 Define Success

> *What is the minimum amount of work necessary for this work be publishable?*

To publish a full paper, ideally an controlled experiment with animated vs non-animated feedback would be conducted. Anything that has the potential to show the difference could be publish. In the context of this class, however, a pilot study with 10 participants may be more suitable to get an idea for how viable an experiment like this is.

References

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