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Poster

Parallax-based Glyph Composition Technique with Colour-Blending Glyphs

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Abstract

Stacked is a glyph composition technique which relies on the parallax effect achieved through AR: multiple glyphs float on top of each other. Although the individual glyphs are spatially separated, changing viewing angles can compose or decompose the glyphs. In the area where the glyphs visually align, their colours are multiplicatively blended to express multiplied values. We compared the novel technique against a control technique, Radial, which cannot be decomposed. We found increasing the number of glyphs in a composite reduced the accuracies of both techniques. However, Stacked was more affected. Participants were faster with Stacked technique when the composites were far away; the parallax effect automatically decomposed the far-away glyph composite.

CCS Concepts

• ***Human-centered computing*** → ***Visualization design and evaluation methods;*** • ***Computing methodologies*** → ***Mixed / augmented reality;***

1. Introduction

Glyphs are markers used in visualization [BKC*13]. Multiple glyphs can be composed into a single one to convey multivariate information [ROP11]. We introduce a new glyph composition technique called Stacked that uses the parallax effect to compose the glyphs. A user changes their viewing angle to examine glyphs' components. Where the glyphs overlap, the colours are multiplicatively blended to indicate multiplied glyph values. Stacked was compared against Radial (a.k.a Mondrian) which we developed for an augmented reality (AR) + tablet system for room-size geospatial analysis [HR23]. Radial, unlike Stacked, was a strictly 2D technique and its composite cannot be altered through the parallax effect. We conducted a 16-people study (8 Females, 7 Males, 1 Other) similar to Jankun-Kelly et al.'s study [JKLSI10]. Each participant viewed a single glyph composite at a time and indicated their values. Our study's main purpose is to better understand user effectiveness with the parallax effect. This work complements [HR23] which focuses on large-area glyph fields.

2. Method

For each participant recruited from Dalhousie University, we administered a 16-plate Ishihara test to determine if they have colour-vision deficiency; all passed the test. We seated them in a swivel chair close to a tablet (Surface Book 3 with a 15in screen) and asked them to wear a MS HoloLens v2. We disallowed them from moving the chair. We propped the tablet up so that it would be angled at 60^o to allow Stacked glyphs to blend automatically with minimal head rotation. Participant ID number determined the technique order. During training, GCS progressively increased–starting with Single glyphs, then Double (2-glyph composite), then Triple (3-glyph), and finally, Quad glyphs (4-glyph). Also, the distance increased–from 0m, to 0.2m, and finally 1.5m left of each participant. To complete a trial, the participant performed the following: **STEP 1.** Clicked on the start button or the words "Click to begin the trial." **STEP 2.** Visually located the glyph–if the glyph was not at 0m, a left-pointing arrow appeared as a guide on the tablet. **STEP 3.** Reviewed each glyph component and indicated its value using sliders presented on the right side of the tablet. Additionally, identified the multiplicative blended value of the area where all constituent

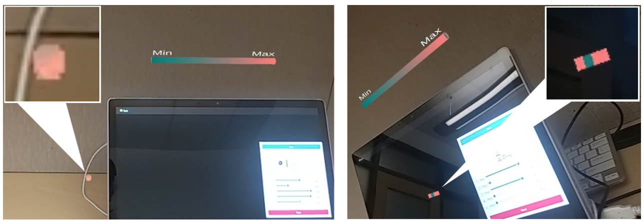

Figure 1: *LEFT: Radial (GCS is Quad glyphs, distance = 0.2m) as appeared to P6. The inset shows a close up view of the composite. RIGHT: Stacked (GCS is Quad, distance is = 0m) as appeared to P6. The glyphs were slightly decomposed as P6 was looking from the side. The inset shows a close up view of the composite.*

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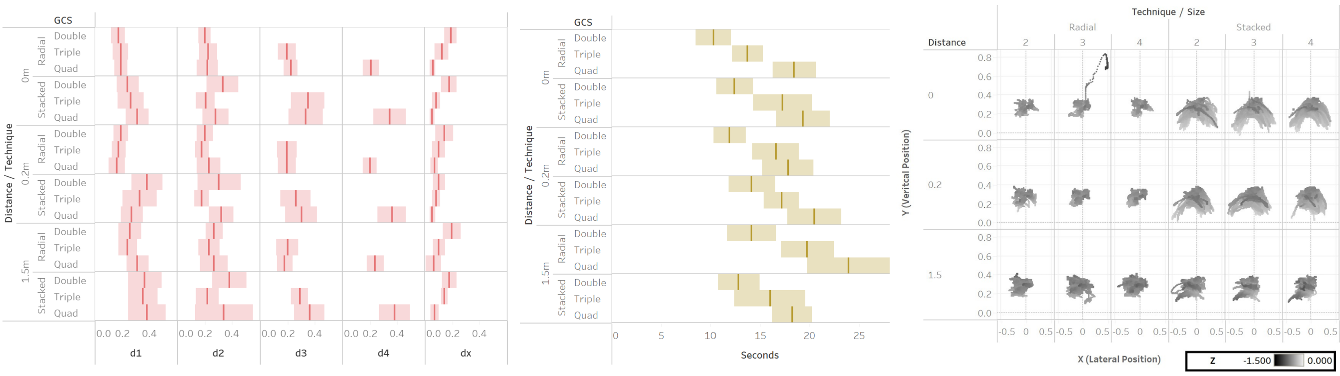

Figure 2: *LEFT: Medians and 95% confidence intervals (CIs) for accuracy (lower is better). d1-4 refers to the errors of glyphs inside a composite; dx is the error of the blended value. MIDDLE: Medians and 95% CI for duration (lower is better). RIGHT: Head movements.*

glyphs overlapped. **STEP 4.** Clicked on "End Trial." In total, 54 experimental trials were performed with the same technique. We randomly varied: (1) colour values (randomized between 0.0 to 1.0 inclusive, step = 0.1), (2) distances (0m, 0.2m, 1.5m left of the participant), and (3) GCS (Double, Triple, Quad). After the 54 trials, a questionnaire was administered and the participant then repeated the training and 54 trials with another technique. Please refer to the supplementary materials for the questionnaire results.

3. Analysis

For accuracy, an omnibus PERMANOVA and post-hoc PERMANOVA tests with Gower distances and GCS as the strata were used to compare the absolute differences between the correct values and the participants' values. The interaction between Technique and GCS was statistically significant ($F_{1,1719} = 15.540, p = 0.001, R^2 = 0.007$). Increasing GCS adversely affected both techniques ($F_{1,1719} = 415.990, p = 0.001, R^2 = 0.183$), but had more impact on Stacked ass seen in Fig. 2-LEFT. The participants' pre-existing bias, possibly SNARC (see [SF18]), may have caused them to read Stacked glyphs in reverse order. Distance was statistically significant but had a small effect ($F_{1,1719} = 10.300, p = 0.001, R^2 = 0.006$). Extra head movements (Fig. 2-RIGHT) from Stacked affected accuracy, but very minimally ($F_{1,1719} = 5.860, p = 0.002, R^2 = 0.003$). For trial durations, an ART-ANOVA test determined that a three-way interaction effect exists for Technique, Distance, and GCS ($F_{4,1695} = 2.44, p = 0.045, \eta^2_{partial} = 0.006$). However, the two-way effect of Technique x Distance ($F_{2,1695} = 2.257, p \leq 0.001$) had a larger effect size ($\eta^2_{partial} = 0.03$). Post-hoc tests found Stacked was faster than Radial at 0.2m ($t_{1695} = 5.901, p \leq 0.05, d = 0.143$) and 1.5m ($t_{1695} = 5.733, p \leq 0.05, d = 0.139$)–meaning, if the composites were further away, the ability to decompose glyph composites reduced trial durations.

4. Discussion and Conclusion

When GCS increased, the accuracy was lowered–particularly for Stacked. However, Stacked was faster when the glyphs were further away because the parallax effect automatically decomposes the glyphs. The teal-pink colourmap (seen in Fig. 1) was used because a pilot study showed it was sufficiently isolumiant. Other less isoluminant colourmaps could introduce transparency as a confounding variable due to an OST-HWD rendering dark colours as transparent [ILSP21]. Future studies should explore other colourmaps and composition techniques.

5. Acknowledgements

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