TVCG Amendment Response (TVCG-2022-07-0325)

Before we address the comments and suggestions item-by-item we would like to express our thanks and appreciation for the time and effort reading and evaluating this work.

Reviewer: 1

The following changes have been made from Review 1's comments

(e.g., https://link.springer.com/chapter/10.1007/978-3-319-66435-

Comments	Change/Response
1) External validity: especially considering the statement made by the authors (Section III-F: "This restriction is used on the premise that linear projections and biplot displays will not be regularly used for consumption by general audiences"), I would question the realism and generalizability of the experimental conditions and the synthetic data as compared to the potential real-world scenarios. I would argue that when high-dimensional data exploration techniques are required by users (including the investigation of cluster/class separability, among other tasks), the dimensionality of the data might very well exceed 6D and get into tens/hundreds/thousands of dimensions in some cases (e.g., consider embedding vectors produced by modern artificial neural network models). I would not ask the authors to repeat the study with 7, 8, 100-dimensional data, of course, but I would expect the discussion of such limitations and implications for real-world data scenarios to be extended in the manuscript (on a side note, it would be interesting to imagine how the used interface and biplot would look like with 100 dimensions, and how much time would a meaningful grand tour take).	We have changed the introduction and limitations to reflect this point. We agree that linear projections are not a panacea for multivariate visualization, but going to 4 or 6 dimensions does extend the reach of the fidelity of visuals especially when used with dimensionally reduced spaces.
2) Motivation for particular visual factor choices: since the study was designed with "modest" data dimensionality (Section III-C) and difficulty in mind to be feasible in a crowdsourced setting, I am wondering why a SPLOM (or perhaps a PCP as well) was not considered as another baseline approach that would probably be familiar or intuitive to the participants. Actually, either a SPLOM with the original 4/6 dimensions, or a SPLOM with PCs (similar to Fig. 2) could have been an option	We have clarified the section Visual Factors. We agree that SPLOM or PCP could similarly visualize these spaces. However, we wanted focus on the difference of the manual tour In relationship to its nearest neighbors. For this reason, we stuck with visuals with a single biplot display for a more apples-to-apples comparison.
3) Related work discussion: the authors have presented a very nice overview of the multivariate/high-dimensional data visualization landscape, and combined with the survey by Lee, Cook, and others (2022) and further surveys and original research contributions mentioned in the manuscript, I think the main topic is covered well. Still, I would like to note that approaches other than projections should be briefly acknowledged as potential options in Section II, e.g., glyphs or pixel-based techniques. I also think that the prior work discussing the challenges of crowdsourced evaluations for InfoVis is very much relevant to this work	We have changed the wording in the Background to include a discussion of this. While it isn't the primary focus of this work these concerns are worth noting.

4_2 and https://link.springer.com/chapter/10.1007/978-3-319-66435-4_5), and the respective concerns could be elaborated on further.

- 4) Presentation: ... TVCG template ... IEEE referencing style is required to be used, to the best of my knowledge.
- extra material from the appendix to supplementary material.
- Figure spacing: Fig. 4 so that it takes half a page with respect to the vertical space. The size of Figs. 5 and 6 could be decreased too, perhaps. If some extra space is available in the main part of the manuscript, I would suggest moving Fig. 9 here, even if shrunk to some extent.
- ... proofread the manuscript carefully once again. Some examples of minor issues and typos that I have noticed are listed below.
- bibliography also includes several entries with missing fields, incorrect DOIs, and in lined code (please check the reference for Nam and Mueller):

- The attached response has been compiled in TEX directly with the TVCG template.
- -The appendix has been moved to supplementary material.
- Figure spacing and dimensions have been adjusted for less white space through-out
- We have proofread again, thank you.
- About 10 bib citations have been updated or improved.

Reviewer: 2

configuration of the axes:

The following changes have been made from Review 1's comments

Comments	Change/Response
A1) The problem in dealing with the Grand Tour and the PCA Tour (aka Radial Tour)[sic] is that the distortion properties are not constant in the embeddings, i.e. distance properties in the plots of the data vary across the tour, meaning the analysis is biased. Therefore, the orthographic tour was introduced in [1], which	The original submission had discussed this in II B, 1 & 3. Each frame of the grand and radial tour is indeed a linear, orthographic projection. There is no idiosyncratic distortion of the space.
guarantees to minimize distortion properties (across the tour). [1] is referenced in the draft, but there is no deeper discussion and consideration of the orthographic tour within the draft.	
A2) The problem of the Grand Tour and the PCA tour (also the radial tour) is that these tours grow quadratically with the number of dimensions n, causing them to scale poorly.	In the section II D, we have add 2 paragraph expounded on the discussion on view time and observing
Therefore, an optimal tour was introduced in [2], which allows the data set to be fully explored, but only grows linearly in the number of dimensions n. In concrete terms, exactly n/2-many projections are required to explore nD.	p-dimensions leading to poor scaling including reference to [2]. We also tie this discussion in with projection pursuit and note that the objective function is a subjective choice of the
Thus, the optimal tour scales better than all other tours, and even better than a bivariate SPLOM which requires n² many plots (the PCA tour also requires n² many plots). There is no deeper discussion and consideration of the optimal	analyst, not a wholistic viewing of p-space.
tour from [2] within the draft.	[2] Optimal Sets of Projections of High- Dimensional Data
B) Comparison is not plausible	We have clarified the selection and justification of visual methods selected
The comparison, e.g., between radial tour and grand tour is not plausible. A problem with multivariate linear embeddings is that the structures of the data visible in the embeddings depend on the	in section III B.

Both, the angle and the magnitude are relevant.

The grand tour tries to counteract this:

The grand tour is a data-driven process and fundamentally capable of displaying important structural properties of the data by varying different axis configurations.

The radial tour, on the other hand, fixes any angular configuration and thus severely limits the space for explorable structures. Only the variation of the magnitude remains now.

As a result, this method is fundamentally incapable to explore the structural space in the same way as the Grantour can.

Comparing both methods with each other is therefore pointless.

As stated in the paper, the radial tour is designed to study "Variable Sensitivity" (aka Feature Engineering).

BTW: Variable Sensitivity is a topic that has already been well researched, e.g. in the papers [6] [7] [8], which is also not considered in the draft.

However, The Gran Tour, on the other hand, is designed to provide information about the (global) structure formation in the data

To compare both methods - as happened in this draft - therefore isn't reasonable at all.

This is discussed in one of the newly added paragraphs in section II D.

The grand tour and radial tour are directly comparable as both can vary the basis. They differ in the agency of controlling the basis. While the grand tour shows more different frames faster, the radial is a tool for the analyst to control at their own pace. (Note that the grand tour selects target bases at random not an optimization of the data.)

Variable sensitivity should not be equated to feature engineering or feature selection. The later two are part of the preprocessing of the data. The former is the act of evaluation of the impact of the feature, which may impact its inclusion. We will try to draw out this distinction

We have clarified these sentences to convey the intended meaning.

We disagree on the second point, biplots do not aim to preserve accuracy; they preserve it because they are only valid to show for linear, orthogonal projections. If you read the flow of the background, I think it becomes clearer that we specifically only focus on linear, orthogonal projections and have described the case that deviates from this.

C) Many content errors

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> => here are a few examples

>

> => P.6 "Orthogonal visualizations either scale poorly with dimensionality or

introduce an asymmetry of the variable ordering.

> => thats wrong. In [2] is a orhtographic tour introduced that scales linear in the number of dimensions, which

> is the best approach we have till today: even better w.r.t. scaling properties than PCA-tour and simmilar approaches.

> >

>

> => P1. "when accompanied by a representation of linear combination of the original variables, they are called biplots"

> => thats wrong. Linearly combining variables to get embeddings is a hige field of appriaches. Biplots are just a very special case: In biplot, the aim is to preserve accuracy.

> If A ist the projection matrix for a linear multivariate projection, then:

> each A with A^T*A=I gives a biplot (I...Unity Matrix). BTW: if you select A with A*A^T=I you get an orthographic projection.
> See [5] for details.

D) Hints:

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> - A lot content has been taken from OSC [1], especially on the first few pages, but without setting any reference to it.

This is a difference in source material and thinking. We are building from the original Asimov 1983 founding of tours

>	rather than the later OSC
> - The study design is on a very basic level (please study Tamara Munzner et al.) .	interpretation of getting to the tour.
> - proofread is needed	We cite Munzner through-out, I am not sure which citation you are referring to.
	We have conducted another proof read after applying changes to the review comments.

Reviewer: 3

The following changes have been made from Review 1's comments

Comments	Change/Response
How were radical tours generated? I still don't quite understand how radical tours were generated. I read the introduction "The radial tour (Spyrison and Cook 2020) is a variant of the manual tour that fixes the contribution angle and changes the magnitude along the radius." and the left column on Page 4. Could these be rewritten as equations or formulas? Or can the manuscript provide a plain and concise explanation with respect to base/basis? The terms "radius" and "frame" appear	We have clarified the explanation f biplot and basis in the introduction and have removed most cases the term 'frame' in favor of basis or projection. Radius is the normal English usage.
unexplained.	We really don't have space to rehash the creation of the manual tour here as it isn't central to this user study. We demonstrate the process fairly clearly in the cited work.
Improvement and simplify the description of the accuracy measure.	We have clarified the accuracy measure and x bar.
Clarify the experimental design	Agreed, we have changed the wording through-out to reflect the mixed design
Simplify the description of experimental design.	We have swapped figures in the text and supplemental materials for simplicity and changes the text accordingly.
Simplify data analysis and improve the notation style	We have touched up the notation for clarity
Detailing the result reporting.	We have applied most of the suggestions here.
The discussion section is a bit too concise	We have expanded the discussion section and linked this work back to the existing literature. We have also moved the limitation up from the conclusion and expounded upon them.
Minor comments	Change/Response

I feel Fig. 2 is not very useful for the work. It services related work but not the research.	We feel that figure 2 is a good representation of the ballpark difficulty of the data simulation. This is not show visually in other figures.
Related work - 3) Nonlinear: it should acknowledge common nonlinear embeddings like t-SNE and UMAP.	This is beside the point, but they have been added.
The title is long and awkward: "A Study on a User-Controlled Radial Tour for Variable Importance in High-Dimensional Data" or similar should be good enough.	The title has been changed.
I may suggest sticking with the term "tours" because visual method has a few meanings: visualization (the same) and animation (not the same).	PCA is not a tour, so the encompassing term is visual method.
It is usually a good thing to submit code for review. However, please also prepare a README file to convey how the repo is organized.	A README file has been added to explain the repository organization.
I didn't find participant data in the repo, or it is hidden deeply.	This has been clarified in the README. (It's in the data folders).
I am still skeptical about the use of Prolific participants. If their degrees are not in a related field, then the claims of how they represent the target users (data analysts, scientists, etc.) are questionable.	This has been discussed as a limitation.
As the manuscript states, PCA preserves variable variance but not clusters (e.g., not like t-SNE), is there a justification for using PCA for this task? I may have missed it. Such a justification should be more explicit.	Because it's a linear method (unlike tsne), This has been pointed out, but will re-emphasize.
The manuscript may not be using the correct Latex template. Please double check TVCG's guideline on formatting and I think the header should be \documentclass[10pt,journal,compsoc]{IEEEtran}.	Done, thank you.

Nicholas Spyrison

30 December, 2022