**COVER LETTER**

**Submission ID**: 1041

**Revised title**: AnthroVis: Visual Analysis of 3D Mesh Ensembles for Forensic Anthropology

**Date**: April 10th, 2017

We would like to thank the anonymous reviewers for their helpful comments. We attempted to address all remarks in the revised version of the paper.

In this letter, we give detailed responses to all reviewer comments and describe the corresponding changes in our manuscript.

**Primary review**

1. *Related work:*

*Similarity matrices are frequently used to show the similarity between many objects. Haidacher and Bruckner (Volume Analysis Using Multimodal Surface Similarity), for example, uses a similarity map to compare isosurfaces (computed with different iso-values).*

*Also, comparing isosurfaces on a cutting plane is commonly used, for example, in meteorology where so-called Spaghetti plots are used. Demir et al. (Screen-space Silhouettes for Visualizing Ensembles of 3D Isosurfaces), for example, show view-dependent silhouettes of 3D meshes.*

The requested publications were added to the Related Work section.

1. *The method heavily depends on the initial alignment of the models and the  
   establishment of correspondences to an average mesh. The authors use an alignment based on IPC and a nearest neighbor search for correspondence establishment. The used methods are rather sketched than described in sufficient detail to allow reproduction. For the IPC it is not clear which variant is used. As the original version is not very robust I was wondering if the authors really used this. Also in the average mesh computation I was wondering whether choosing the nearest mesh vertex really gives good results. For the proposed test case with faces the assumptions of IPC that a rigid transformation* *is sufficient for alignment does not hold as one has to consider a complex deformation space.*

We are using the scaling variant of the Iterative Closest Point algorithm (ICP). In our system we offer the version with vertex to vertex matching as well as the variant with vertex to nearest point on surface search which is computationally more demanding, but provides more precise results. Same approaches can be used for average mesh computation.

The usage of non-rigid transformations in the ICP algorithm is optional for domain experts, as these transformations could eliminate important information from the data, e.g., scaling could interfere with size changes when analyzing the facial development of a growing child.

The corresponding paper sections were edited to include this information.

1. *The authors did not discuss this issue nor how their visualization techniques would be influenced by a natural facial deformation. I believe that a more suitable establishment of surface correspondences would lead to much better results in average mesh computation and visual analysis. A step towards this could be the integration of alignment into the visual analysis tool for example by support for re-alignment of a selected region on the average mesh.*

The suggestion to re-align the mesh according to a selected region of the facial mesh is very relevant and it is exactly one of our subsequent steps in this project. This functionality was already required by the anthropologists as well. Therefore, we added this to the Future Work section.

1. *The evaluation of the presented method is rather weak and does not allow to  
   ultimately decide whether the approach works correctly or is utile in other  
   application domains. Comparison is only done with respect to the approach used  
   previously by domain experts and not to existing visual analysis techniques  
   discussed in the related work section. I would have expected some experiments with an evaluation data set where domain experts searched for a face in a data base and either had to find a corresponding scan from the same person or state that the person was not yet in the data base. Such an experiment would then allow comparison to other approaches like the one the domain experts used before.*

The proposed tool was designed to cover namely the specific needs of our cooperating group of anthropologists. Their typical scenarios are covered by the presented use cases. The basic experiments the reviewer is mentioning were conducted within the development phase because they can easily reveal if the algorithms are correct. Therefore, as these experiments are basic and cover only a naturally expected functionality, we decided to demonstrate the usability of our tool on more complex and interesting problems the anthropologists have to face. However, we agree that a proper usability study ought to be conducted in the near future.

We also added the information about tools used by anthropologists prior to AthroVis to the related work section, to provide the readers with better comparison with our tool.

1. *Another interesting experiment could study the effect of facial animation of the same individual on the alignment, comparison and visualizations*.

With the currently used database of facial expressions, it is impossible to conduct such an experiment. The database contains meshes capturing neutral facial expression – this was one of the preliminary requirements of anthropologists. But we agree that this could be useful testing scenario.

1. *There should also be some evaluation on performance of the approach. I did not find timing measurements for the individual steps of the pipeline. It would also be interesting to have some more details on what was implemented on the GPU and how this was implemented.*

The main contribution of our work lies in the proposed visual analysis tool which is tailored to the specific needs of anthropologists. The computationally demanding parts, such as alignment and average mesh computation are highly dependent on the input dataset. However, the time performance of these steps does not play key role for the domain experts, as they are done prior to the visual analysis. Once the precomputations are done, the visual analysis tool performs in real time, independent of data size.

As for implementation details, we stated in the paper that the individual visualization techniques and their implementation are already described in:

Furmanova, K.. Visualization techniques for 3D facial comparison. In: Proceedings of the International Summer School on Visual Computing. ISBN 978-3-8396-0960-6; 2015, p. 23–33.

1. *A figure could help to explain the average mesh computation.*

Figure 4 illustrating one iteration of the average mesh computation was added to the paper.

1. *Fig. 2 does not correspond completely to the description in the text, I suggest to modify either the labeling in the figure, or the explanation.*

Labeling in the Figure 2 was corrected.

1. *The contours in Figure 3 are very strong visual cues but are probably heavily dependent on the alignment algorithm and should therefore be also visualized with much less emphasis.*

In our system the emphasis on the contours (color and thickness) can be interactively adjusted. Figure 3 was adjusted to show results with less emphasis on the contours.

1. *The authors did not specify how fog was evaluated.*

Fog simulations were evaluated as a part of the superimposition technique. The wording used in the Discussion section was adjusted to state this more clearly.

1. *The section labeling 4.0.1, 4.0.2, … needs to be corrected. Section 4.0.x - it is not a habit to have sections numbered zero.*

The section labeling was corrected.

1. *A discussion on the scalability of the approach to thousands and millions of 3D meshes should be added.*

AnthroVis is focused primarily on the datasets of facial meshes captured by anthropologists. The currently available datasets contain units of thousands of models and it is not expected that their size would increase dramatically. Additionally, the cooperating anthropologists are operating maximally with hundreds of meshes at once. Therefore, our proposed methods are applicable to such amount of data and some substantial scalability is not desired now.

1. *Typos:  
    -  last sentence in 4.0.2 - a given target meshes -> given target meshes*

*- anthropological \_expertize\_ -> expertise?*

*- of such situation is -> of such \_a\_ situation is*

*- readers with more detailed -> readers with \_a\_ more detailed*

*- based on \_the\_ color mapping -> based on color mapping*

*- one mesh \_form\_ the analyzed -> from?*

Typos were corrected.

1. *In order to accent the novelty, I would recommend to include more arguments about what is novel from the information-visulization point in the presented software.*

We are not claiming any novelty for InfoVis as we are utilizing traditional techniques for conveying individual comparisons. However, the novelty lies in the proposed visual analysis tool which is tailored to the specific needs of anthropologists. We tried to clarify the contribution to avoid this confusion.

1. *Also, the authors in the introduction name several problems of the existing approaches but they should clearly state how their suggested combination of  
   visualization techniques solves (some of) the shortcomings of the previous  
   approaches.*

The Discussion section was edited to clarify the contribution more clearly.

**Secondary review I**

1. *It would have been helpful if the authors would have presented some other applications in order to be able to estimate the general value of the presented tool.*

See response to comment no. 4 in the primary review.

1. *The method heavily depends on the initial alignment of the models and the  
   establishment of correspondences to an average mesh. The authors use an alignment based on IPC and a nearest neighbor search for correspondence establishment. The used methods are rather sketched than described in sufficient detail to allow reproduction. For the IPC it is not clear which variant is used. As the original version is not very robust I was wondering if the authors really used this.*

See response to comment no. 2 in the primary review.

1. *Also in the average mesh computation I was wondering whether choosing the nearest mesh vertex really gives good results. For the proposed test case with faces the assumptions of IPC that a rigid transformation is sufficient for alignment does not hold as one has to consider a complex deformation space.*

See response to comment no. 2 in the primary review.

1. *The authors did not discuss this issue nor how their visualization techniques would be influenced by a natural facial deformation. I believe that a more suitable establishment of surface correspondences would lead to much better results in average mesh computation and visual analysis. A step towards this could be the integration of alignment into the visual analysis tool for example by support for re-alignment of a selected region on the average mesh.*

See response to comment no. 3 in the primary review.

1. *The evaluation of the presented method is rather weak and does not allow to  
   ultimately decide whether the approach works correctly or is utile in other  
   application domains. Comparison is only done with respect to the approach used  
   previously by domain experts and not to existing visual analysis techniques  
   discussed in the related work section. I would have expected some experiments with an evaluation data set where domain experts searched for a face in a data base and either had to find a corresponding scan from the same person or state that the person was not yet in the data base. Such an experiment would then allow comparison to other approaches like the one the domain experts used before.*

See response to comment no. 4 in the primary review.

1. *Another interesting experiment could study the effect of facial animation of the same individual on the alignment, comparison and visualizations.*

See response to comment no. 5 in the primary review.

1. *There should also be some evaluation on performance of the approach. I did not  
   find timing measurements for the individual steps of the pipeline. It would also be interesting to have some more details on what was implemented on the GPU and how this was implemented.*

See response to comment no. 6 in the primary review.

**Secondary review II**

1. *Related work:*

*Similarity matrices are frequently used to show the similarity between many objects. Haidacher and Bruckner (Volume Analysis Using Multimodal Surface Similarity), for example, uses a similarity map to compare isosurfaces (computed with different iso-values).*

*Also, comparing isosurfaces on a cutting plane is commonly used, for example, in meteorology where so-called Spaghetti plots are used.  Demir et al. (Screen-space Silhouettes for Visualizing Ensembles of 3D Isosurfaces), for example, show view-dependent silhouettes of 3D meshes.*

See response to comment no. 1 in the primary review.

1. *Minor typos:*

*- anthropological \_expertize\_ -> expertise?*

*- of such situation is -> of such \_a\_ situation is*

*- readers with more detailed -> readers with \_a\_ more detailed*

*- based on \_the\_ color mapping -> based on color mapping*

*- one mesh \_form\_ the analyzed -> from?*

See response to comment no. 13 in the primary review.