

Craniofacial variation IV: Visualization of surface variation derived from whole head scans

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Abstract A defining feature of geometric morphometric methods is their capacity to produce concise and informative visualizations of population variation, between-population differences, and other multivariate results. With the increasing availability of surface scans, it is necessary to extend the graphical capabilities of the geometric morphometric paradigm to this type of data. Elsewhere, we report on an efficient method for the superimposition of scan samples. Here, we present methods and associated tools for the visualization of that method and its results.

The software we have developed shows the head scan data divided into contiguous regions identified by our scan-fitting algorithm by coloring them differently. In addition, it can generate a color map that represents the differences between two head scans and has the capacity to visualize the magnitude of variability across regions of the skull in a sample of scans fit to a reference. The color and intensity used in the color map correspond to the actual numeric values of the differences between two skulls over the surface or the magnitude of variability over a region for a sample fit to a reference.

Beyond our own immediate needs and interests in advancing research in the design and evaluation of safety equipment, straightforward extensions to our software would make it a useful component of research in other areas, such as studies of modularity and its evolution.

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Introduction

There are three major aspects to the implementation of our visualization method.

- Creating a generic algorithm that reads in and processes data from text files generated by a 3D scanner. The algorithm can be applied to any file.
- Dividing the head scan into sectors of different colors. The sectors correspond to the clusters generated by the Binary Space Partitioning Bisecting K-Means algorithm.
- Generating a color map (heat map) that shows the variance values of a set of head scans in relation to a common "average head".

Tools used

- OpenGL version 3.3
- GLSL (OpenGL Shading Language) version 1.5
- Linux - Redhat
- NVIDIA G84 [Quadro FX 570]
- Java, Eclipse

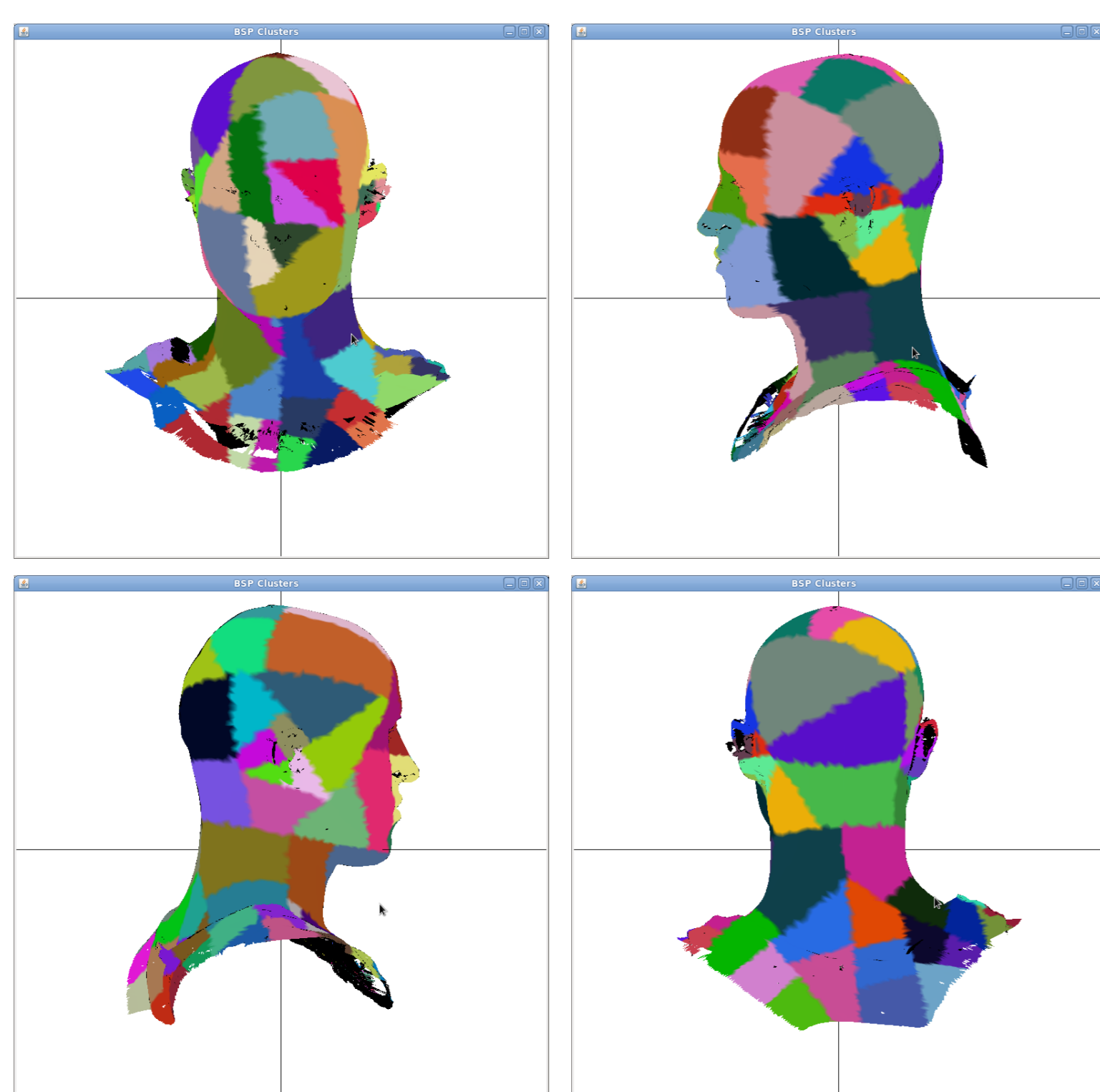
Visualization steps

- Read in and parse data from PLY files. PLY files are essentially list of numbers describing the geometry of an object.
- Store data in appropriate structures. We are using 12 1-dimensional arrays to store the x, y, z coordinates, the 3 vertex indices for each triangle, the RGB values for the colors and the x, y and z coordinates for the normal vector at each vertex.
- Calculate normal vectors for each vertex as the average of the normal vectors of all faces sharing the vertex (this makes the surface appear smooth even though it consists of connected triangles).
- Translate the object to the origin of the coordinate system.
- Scale the object (not always necessary). This is done so that the object fits the viewing volume.
- Generate colors - one RGB color per vertex. Different methods are used for generating the colors for the sectors and the colors for the heat map.
- Add keyboard and/or mouse controls (to rotate, scale and translate the object). This is done so that the user can look at all sides of the object.
- Render the scene.

Part I

BSP Sectors

- 75 BSP Clusters
- Using a random number generator to generate a random color for each sector.
- The user has the option to generate a new set of random colors by pressing a key.

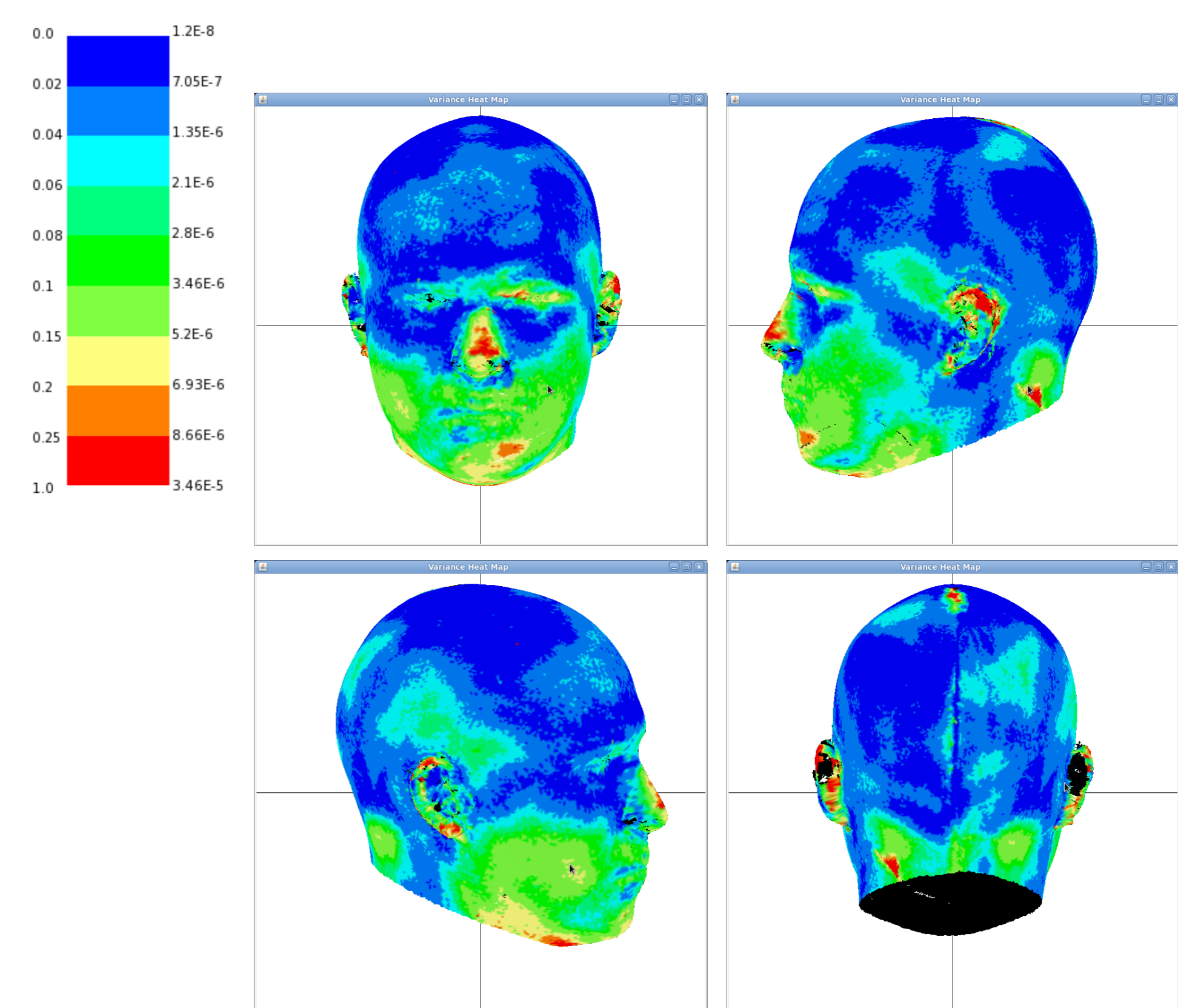


A head scan divided into 75 contiguous sectors corresponding to the BSP Clusters

Part II

Variance Heat Map I

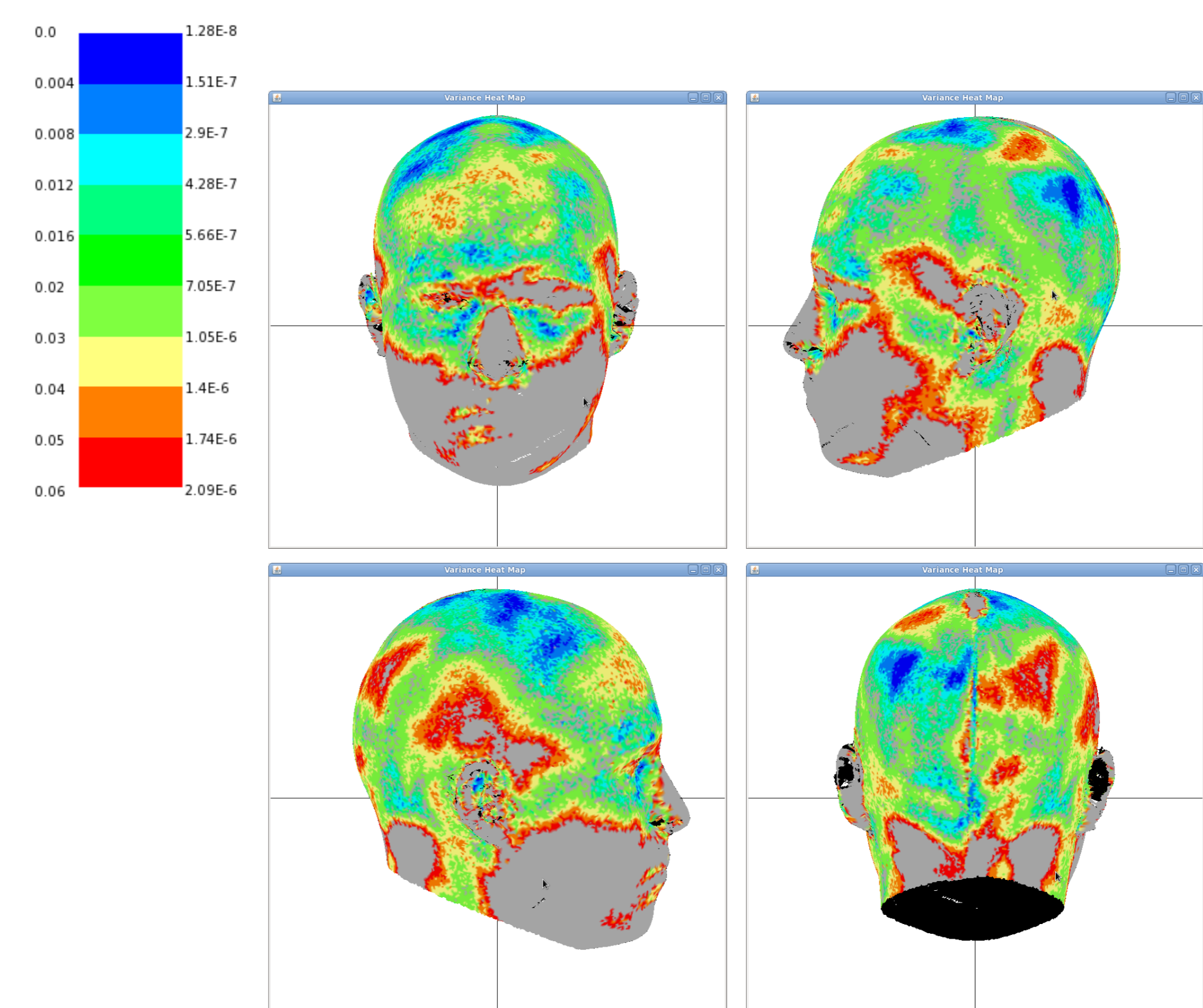
- Scale variance values to be in the interval of 0 to 1.
- Use discrete color values for different values in the interval 0 to 1.
- The heat map below shows the variance over the entire head scan.
- The color bar shows the variance values corresponding to each color. On the left are the scaled values (from 0 to 1) and on the right are the original values.



A heat map representing the variance on the head scan

Variance Heat Map II

- The heat map below shows the variance over selected parts of the head scan.
- The color bar shows the variance values corresponding to each color. On the left are the scaled values (from 0 to 0.06) and on the right are the original values.



A more detailed heat map representing the variance on the head scan. The gray areas represent variance greater than 0.6.

References

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