

Detecting Subtle Facial Dysmorphology in Children with Juvenile Idiopathic Arthritis: Adding Colour Texture to Surface Scans Increases Landmarking Precision Sune Demant^(1,2,3), Nuno V. Hermann^(1,2), Tron A. Darvann⁽¹⁾, Marek Zak⁽⁴⁾, Per Larsen⁽¹⁾, Helena Schatz⁽²⁾, Sven Kreiborg^(1,2,4)

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Background & Purpose

Many studies of craniofacial malformations have employed 3D surface scans, and most often measurements of e.g. facial shape and asymmetry have been carried out based on manually placed landmarks. In one of our current projects on the 3-dimensional physiognomy of the face in Juvenile Idiopathic Arthritis (JIA), subtle variations in dysmorphology need to be detected. As part of this study, the difference in landmarking precision between using a) colour texture (Fig. 1) and b) shaded surfaces (Fig. 2) was investigated.

Null hypotheses

- 1. Precision of landmarking is not influenced by colour texture.
- 2. There is no systematic difference between landmarking positions with and without colour texture.

Methods

18 facial landmarks were manually placed twice, by the same observer, in 30 subjects with JIA, and in two different landmarking tools; 1)"3DM-Dpatient®" (including surface colour texture, Fig. 1) and 2) Landmarker (grey shaded surfaces, Fig. 2). Intra-observer precision was calculated as statistics on distances between landmark positions between first and second landmarking rounds, for tool 1 and 2, respectively, using Dahlberg's formula, (Houston 1983):

$$s(i) = \sqrt{\frac{\Sigma d^2}{2N}}$$
$$d = |x_1 - x_2|$$

Dahlberg's formula calculates a method error s(i), where x_1 and x_2 are 3D coordinates of landmarks at first and second round of landmarking, respectively. Related aspects of validation of landmarks and/or surfaces, may be found in Aldridge et al. (2005), Weinberg et al. (2006) and Larsen et al. (2008).



Fig. 1. Left: Colour textured surface (3dMDpatient) with 18 manually placed landmarks (red). Right: Grey shaded surface with colour of landmarks indicating the method error for the 18 landmarks placed on the colour textured surface, according to the colour bar (mm).

	Colour texture		No texture	
Landmark Name	Mean Difference (mm)	Method Error s(i) (mm)	Mean Difference (mm)	Method Error s(i) (mm)
Porion (right)	0.9	0.8	1.8	1.8
Porion (left)	0.9	0.8	1.7	1.5
Nasion	2.0	1.6	2.1	1.8
Pronasale	1.7	1.4	2.4	2.0
Centerpoint of eye (right)	1.2	1.0	2.2	1.8
Centerpoint of eye (left)	1.4	1.1	2.1	1.8
Exocanthion (right)	1.3	1.0	2.2	1.9
Endocanthion (right)	1.5	1.2	2.2	1.9
Exocanthion (left)	1.4	1.1	2.3	1.8
Endocanthion (left)	1.3	1.0	2.3	1.9
Superciliare (right)	2.0	1.5	2.5	1.9
Superciliare (left)	1.9	1.4	2.8	2.3
Alare (right)	1.9	1.5	2.8	2.3
Alare (left)	2.5	1.9	2.8	2.9
Labiale Superius	1.5	1.1	2.1	2.1
Cheillion (right)	1.5	1.2	2.1	2.1
Cheillion (left)	1.4	1.1	2.2	2.2
Progonion	1.5	1.2	2.3	2.3
Mean	1.5 (SD=0,4)	1.2 (SD=0,3)	2.3 (SD=0.3)	1.9 (SD=0.3)

Table 1. Mean Difference and Method Error s(i) in mm calculated for each of the 18 landmarks, using Dahlberg's formula, in relation to grey shaded surfaces and colour textured sufaces. Landmark showing largest mean difference between first and second landmarking round was Pronasale (grey shaded) and Superciliare (colour textured). Largest method error was Alare(left) (colour textured) and Alare(left) (grey shaded).



Fig. 2. Left: Grey shaded surface (Landmarker) with 18 manually placed landmarks (red). **Right:** Grey shaded surface with colour of landmarks indicating the method error for the 18 landmarks placed on the grey shaded surface, according to the colour bar (mm).



Results

In general, landmarking precision was higher on surfaces with colour texture than on grey shaded surfaces. For colour textured surface scans, mean difference was 1.5 mm (SD=0.4 mm, Max=2.5 mm) (Alare (left)); Min=0.9 mm (Porion (left and right))). For surface scans without colour texture, mean difference was 2.3 mm (SD=0.3 mm; Max=2.8 mm (Superciliare (left), Alare(right) and Alare (left)); Min=1.7 mm (Porion (left)).

Discussion

During the process of landmarking, grey shaded surfaces without perspective provide the possibility of landmark placement using surface topology information alone. Adding colour texture makes it easier to recognize several of the anatomical structures, but can alter the ability of the observer to assess shape information, e.g. related to the midpoint and curvature of a structure.

Conclusion

Both hypotheses were rejected. All 18 landmarks showed higher precision when colour texture was included. Adding colour texture to surface scans increases landmarking precision. On the other hand, experience has shown that it can negatively influence the accurate placement of some landmarks.

References

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