Digital 2D, 2.5D and 3D methods for generating photo-realistic 3D facial depictions of people from the past

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Introduction

The presentation of 3D facial reconstructions as photo-realistic depictions of people from the past to public audiences varies widely due to differing methods, the artists' CGI skillset, and access to VFX software required to generate plausible faces.

This poster describes three methods of adding realistic textures to digital facial depictions produced using 3D software: a 2D photo-composite method, a 3D digital painting and rendering method, and a previously undescribed hybrid 2.5D method. The affordances of each method are summarised.

Background

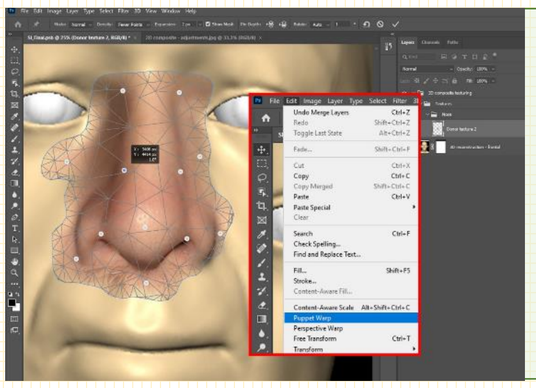
Research has shown that the degree of realism in facial depictions influences their reception by the publics as valid faces (Lewis, 1997; Johnson, 2016), and that faces are generally more difficult to recognise without textural information (Bruce, et al. 1991).

Textural information is therefore an important component of a facial depiction but the desire for hyper-realistic depictions, particularly for museum display, sometimes outweighs available evidence for justification of texture choices; potentially ignoring the fact that the chosen textures are some of many possible options (Wilkinson, 2020).

2D texturing method

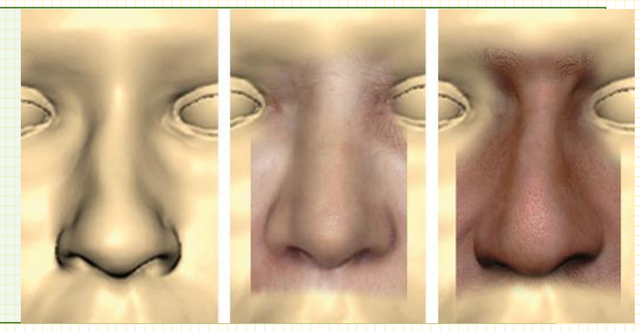
A front-facing still image of a 3D virtual 'clay-like' facial reconstruction is exported from the originating 3D software into an image graphics software. Skin and other complex textures such as hair and clothing are added using donor photographs from face databases, using photo-composite techniques.

Example of digital composite method: 3D digital facial depiction of a 19th century individual unearthed on 'Rat Island', Portsmouth created in Geomagic Freeform, then exported to Adobe Photoshop CC for composite texturing of eyes, hair and clothing. Image courtesy of Face Lab, Liverpool John Moores University.



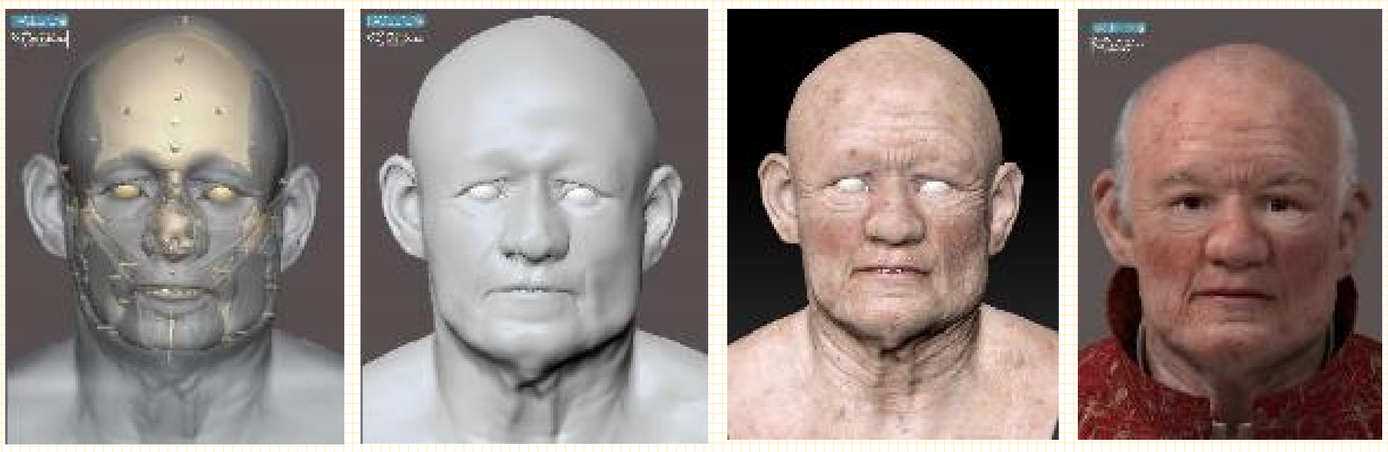
Using tools such as 'Puppet Warp' and 'Liquify' in Adobe Photoshop CC, to place and adjust the position of photographic donor textures atop of a 2D image of a 3D facial reconstruction.

Potential inference of incorrect feature shape from photographic donor images via the 2D digital composite method.



3D painting and rendering method

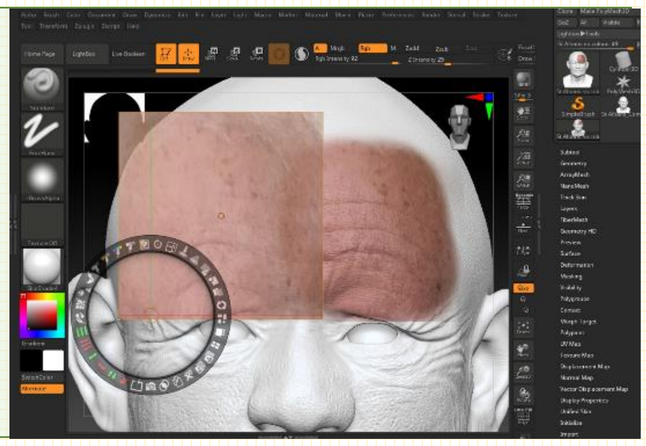
Texture can be digitally painted directly onto the 3D skin surface in software such as Pixologic ZBrush. Once painted, the 3D model can be exported to VFX software such as Autodesk Maya where eyes, hair and clothing can be modelled. The lighting in the 3D scene, and material properties of the skin can be adjusted prior to rendering in Arnold.



Example of 3D texturing method. 3D digital facial depiction of Abbot John of Wheathampstead. Image courtesy of Face Lab, Liverpool John Moores University

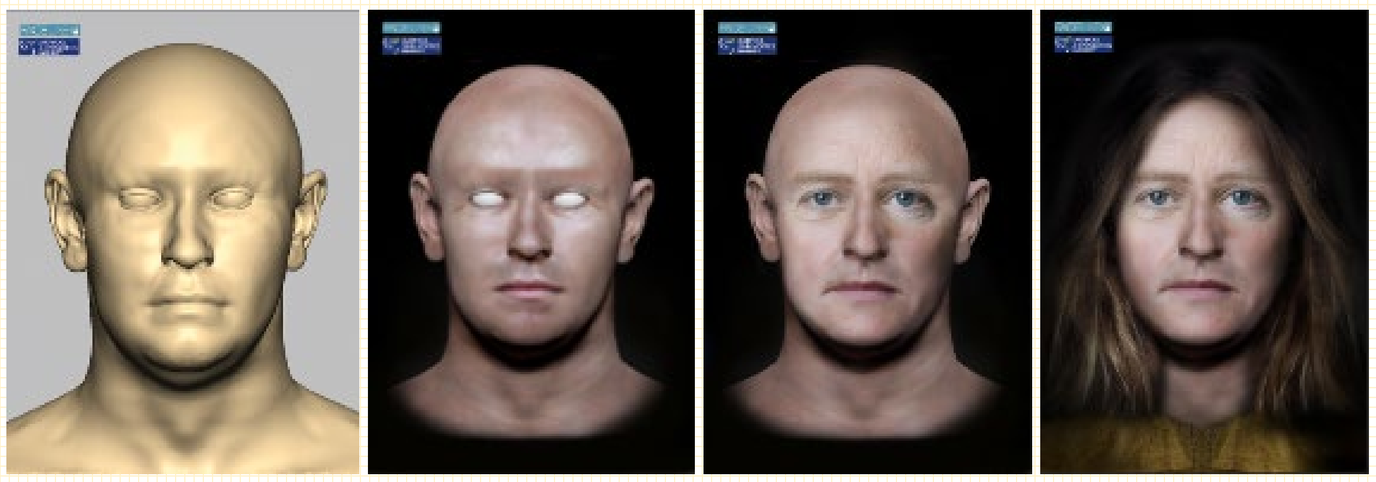
Layering of skin 'textures' through a combined use of sculpting brushes and alphas directly onto the skin layer of the 3D reconstruction model in Pixologic ZBrush

Colour can be painted directly onto the surface of the 3D model using virtual paintbrushes and alphas. Additionally, direct transfer of photographic skin textures to a 3D skin model is possible using donor images and the 'Spotlight' tool in Pixologic ZBrush.

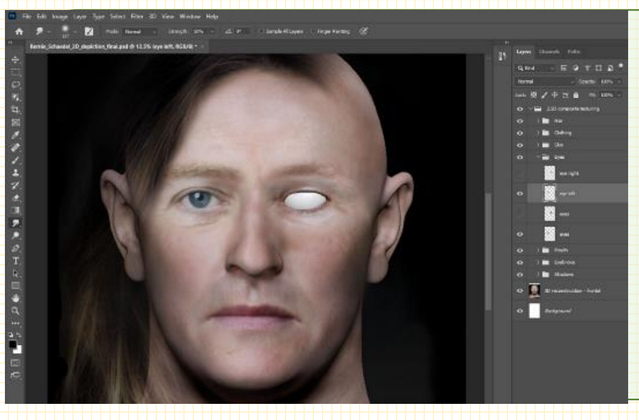


2.5D method

Like the 3D digital painting method, the hybrid 2.5D method adds skin textures directly on the skin layer of the 3D facial reconstruction model. However, more complex textures such as hair and eyes that require advanced CGI skills can be time consuming to generate in VFX software. These complex features is composited on a 2D image of the painted 3D model.



Example of 2.5 texturing method: 3D digital facial depiction of a 1200-year-old bog body known as "Bernie" created in Geomagic Freeform; exported to Pixologic ZBrush for digital painting; exported to Adobe Photoshop for composite texturing of eyes, hair and clothing. Image courtesy of Face Lab, Liverpool John Moores University.



Compositing of eyes, hair and clothing in Adobe Photoshop CC on top of a 2D image of a textured 3D model exported from Pixologic ZBrush.

Affordances of each method

Method	Software	Positive	Negative
2D	Adobe Photoshop CC	Fastest: 8-10 hours. Relatively low cost. Small learning curve.	Photographic donor images could be identifiable. Morphological error between 2D and 3D transfer, due to inappropriate donor image use
3D + Render	Pixologic Zbrush, Autodesk Maya, Adobe Photoshop CC	Shape accurate. Shadows can be adjusted. Model can be viewed and textured from different angles. Multiple display options (static, moving).	80+ hours. Requires advanced texturing and VFX skills.
2.5D	Pixologic Zbrush, Adobe Photoshop CC	Shape accurate. Shadows can be adjusted. 10-20 hours. Quicker to update than 3D method.	Requires some texturing skills and VFX knowledge.

Summary

The 3D painting and rendering method is the the most effective method in adding realistic textures to facial depictions. However, the realism and appearance of the facial depiction depends on the CGI skills of the artist, and additional access to software and hardware is needed for rendering. The 2.5 D method provides an alternative solution/compromise.

The material properties of the skin such as sub-surface scattering, and lighting of the 3D scene can be altered within VFX software in both the 3D and 2.5 methods to produce more realistic outcomes. Shadows are cast on the 3D model from the virtual lights in the 3D scene. These shadows help to define morphology, and the final depiction is therefore unaffected by erroneous shadows from composited donor photographs.

Although the facial reconstruction process is rooted in scientific knowledge, subjective material is often added during the depiction process, especially when the facts prove insufficient for a realistic appearance. This subjectivity is conditioned by confirmation bias and any accepted knowledge/beliefs. The facial depiction practitioner should be aware of their own cognitive biases when applying textures to facial depictions, especially for forensic purposes whereby application of incorrect colour textures can affect recognition.

"No two artists work identically or have identical training" (Erickson et al., 2016). There are no known studies that note if an artists' proficiency with digital texturing software can affect the morphological accuracy of digital facial depictions. Further studies are required to establish this with certainty.