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3D Pose Correction to Improve Automated Facial Recognition Search Results

Facial Recognition System: 3D Pose Correction to Improve Automated Facial Recognition Search Results

Purpose

The purpose of this document is to provide an example of how a current commercial off the shelf (COTS) software package can perform a manual 3D pose correction of off pose facial images. This type of image processing can assist in improving the potential that an investigative lead will be included among the candidates returned, following a facial recognition system (FRS) search of the 3D pose corrected image.

Scope

The scope of this document is limited to showing examples of how manual 3D pose correction can be done to facial images intended to be submitted as a probe image for FRS searches. This document should be utilized after the **FISWG** document “**Image Processing to Improve Automated Facial Recognition Search Performance**” has been reviewed and can assist in the 3D pose correction steps outlined in this FISWG document.

FISWG does not advocate for or recommend the specific software used in this document, it is simply used as a demonstration vehicle to show how 3D pose correction software on facial images with high pose variations (E.g. facial yaw and/or pitch > ~10 degrees in any direction)

3D Pose Correction Software

Anyone who will use 3D pose correction software should take time to review the software usage instructions in order to understand how to properly and effectively use the 3D pose correction. User manuals, online video examples, vendor websites, and specialized training classes are examples of these.

The 3D pose correction topics presented in this document are not intended to override recommendations for maintaining the forensic quality of images intended for one-to-one

comparison. These processes specifically apply to the preparation of a facial image for the purpose of submitting it as a processed probe into an automated FRS search.

Important Notes:

- **Any decision regarding whether or not a particular search candidate and the probe image are from a common source MUST be made based on a comparison with the original (unedited) image and NOT the 3D processed image.**
- The goal of any image processing should be to optimize the image for searching by the FRS, not to create an aesthetically pleasing image. An image that looks 'good' is not necessarily the same as one that is optimized for use by an FRS.
- The effect of any 3D image processing for searching will vary with different FRS and in some cases may not improve your results.
- Any agency using 3D pose correction software should discuss any effects with the provider of the biometric algorithms within the agency's FRS.

The SUFR¹ data set is a set of synthetic images of varying pose which can be used for familiarization of 3D pose correction. A sample of the SUFR data set showing individual models with varying yaw, tilt, and roll can be seen in Figure 1 below.

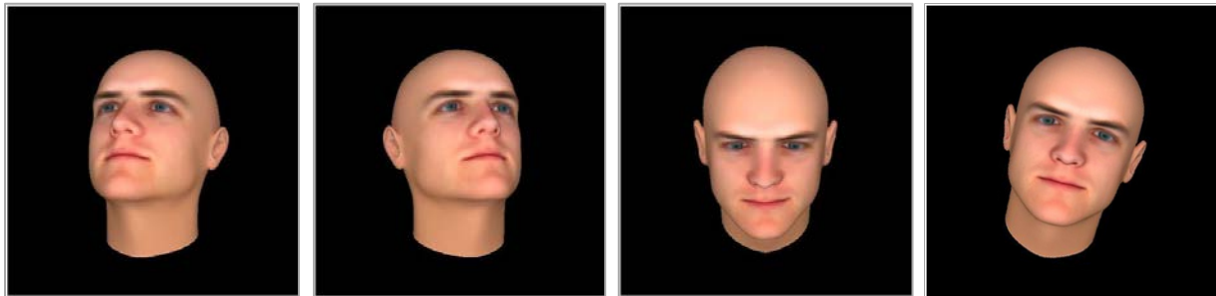


Figure 1: Examples of varying yaw, tilt, and roll

¹ <http://academictorrents.com/details/032b2df1f6f0d75817b0f3af2af9bcdb3a415c37>

Single Image Pose Correction: Angled Subject Pose

1. After starting the 3D pose correction software, select specific configuration parameters for the probe image being corrected. Possible examples of this may include:
 - A metadata category which selects a gender/race model for the image: generic male or female, Caucasian male or female, etc. Small adjustments to the 3D rendered image can be seen when these parameters are adjusted.
 - An image fill option (referred to as “symmetric fill”) which copies image content from the visible portion of the image to the side of the image which is missing.
2. Load the image into the 3D pose correction software (Figure 2). In this example the assumed pose is presented for selection (Figure 3). This will allow confirmation of the proper pose model to be used.

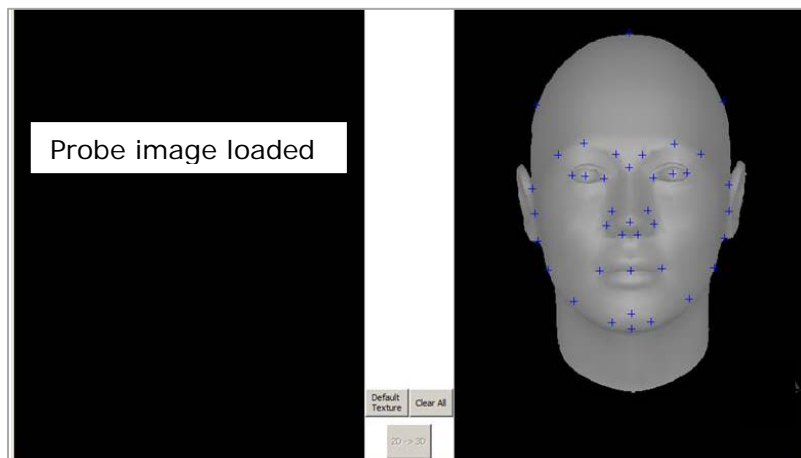


Figure 2

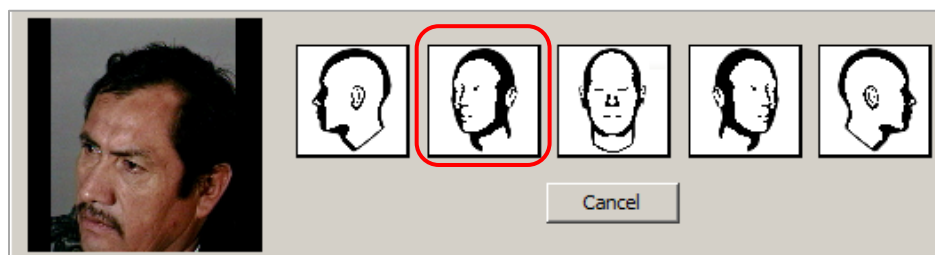
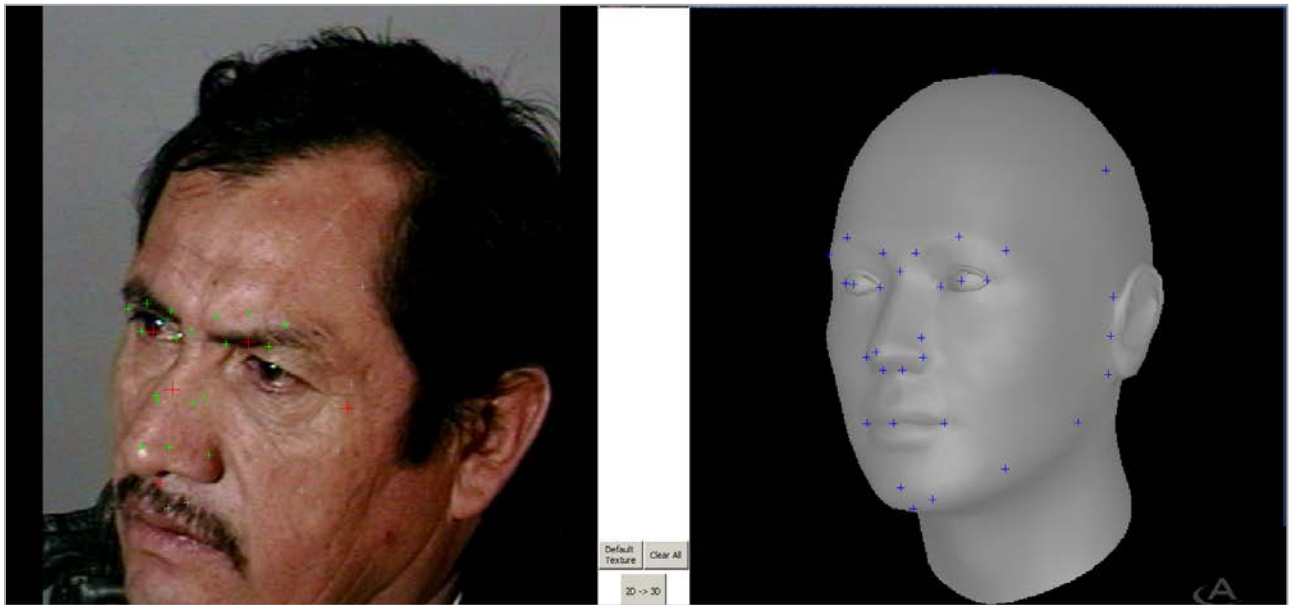
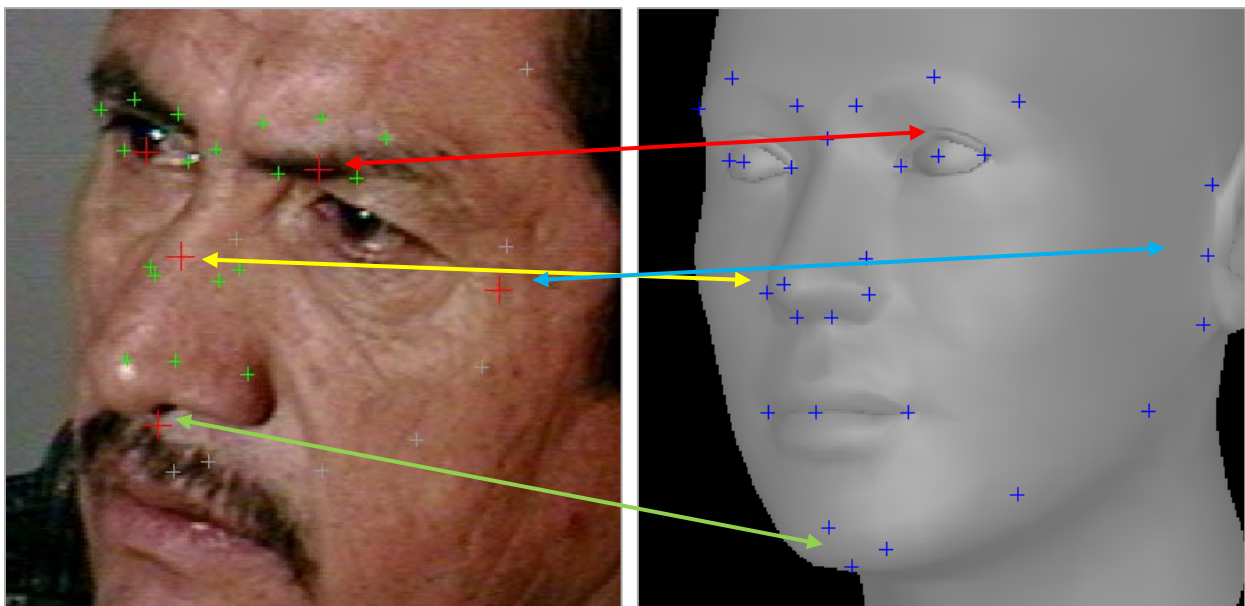


Figure 3

The software will then perform its initial face finding and attempt to locate the correct facial landmarks aligned to the model. In this example the facial landmarks (shown as red and green crosshairs) have failed to properly locate all the correct features (Figure 4).

**Figure 4**

Note how the facial landmarks found on the probe image (Figure 5) are not aligned to the corresponding landmarks on the pose model (Figure 6).

**Figure 5****Figure 6**

To carry out a 3D pose correction at this point, with the facial landmark errors, the initial pose correction output will produce a distorted image as shown below in Figure 7.



Figure 7: Example of a distorted face (right side)

3. Manually adjust the facial landmarks on the probe image (Figure 8) to align with the corresponding landmarks on the pose model (Figure 9).

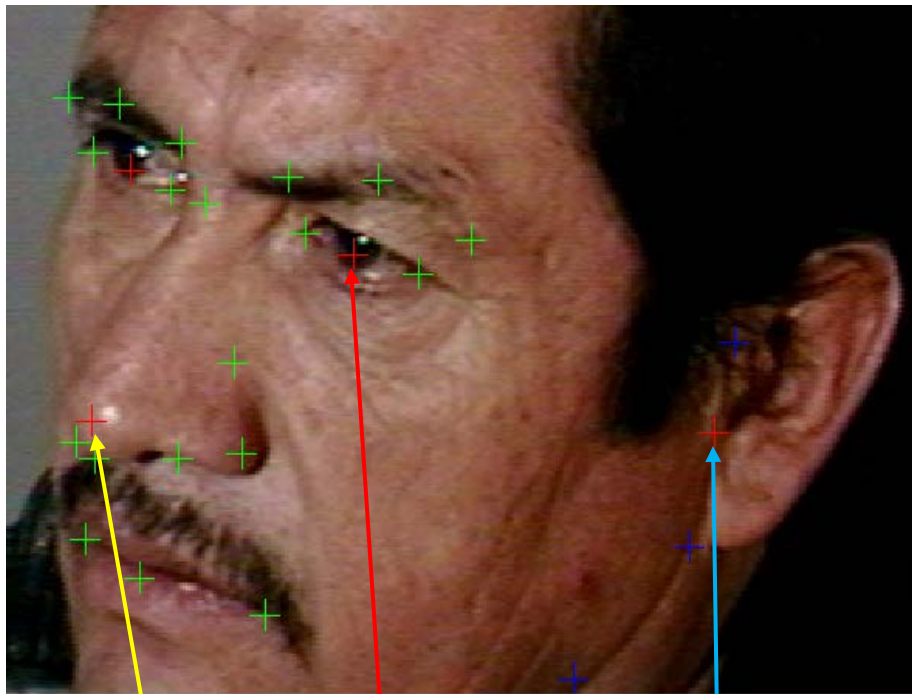


Figure 8

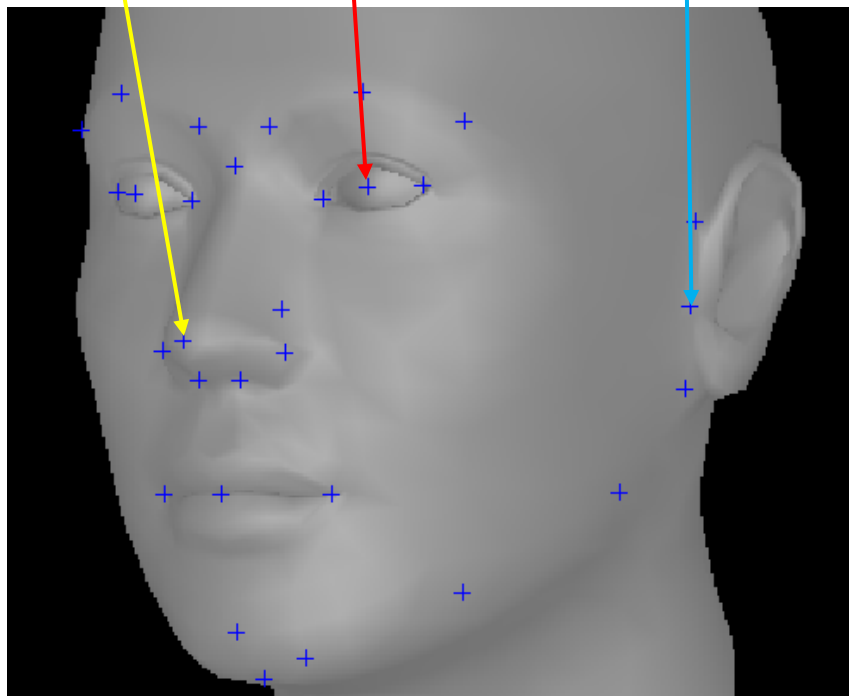


Figure 9

In this specific 3D pose correction software, when a landmark is selected on the probe image (left side) the corresponding feature on the pose model is shown highlighted (right side). See an example in Figure 10.

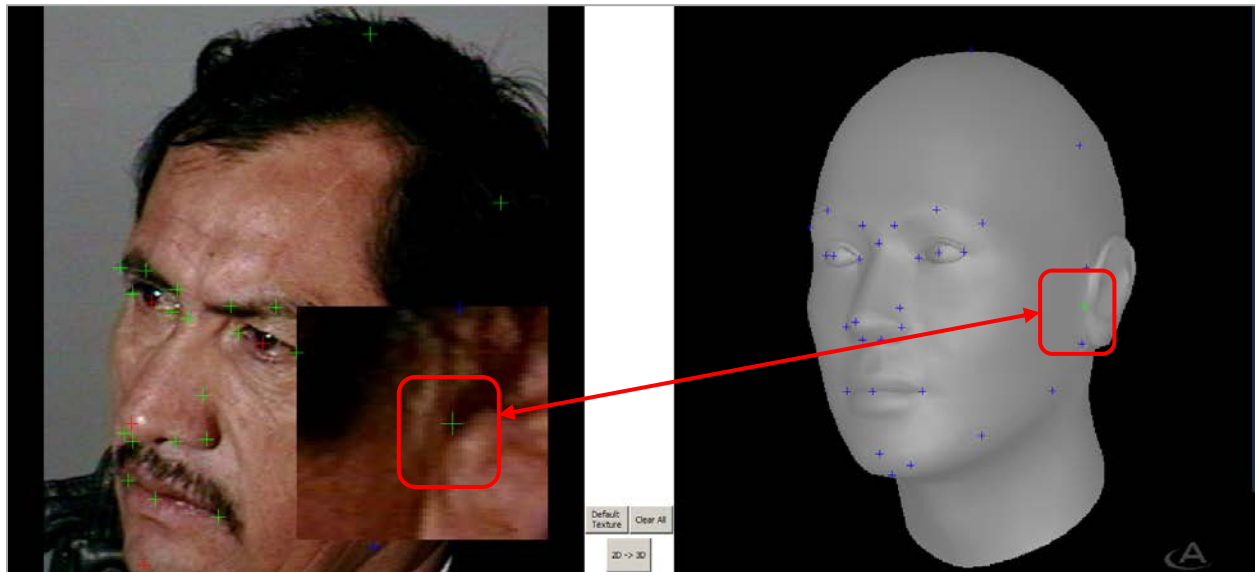


Figure 10

Note how the facial landmarks manually placed (Figure 11) are now aligned to the landmarks on the pose model (Figure 12).

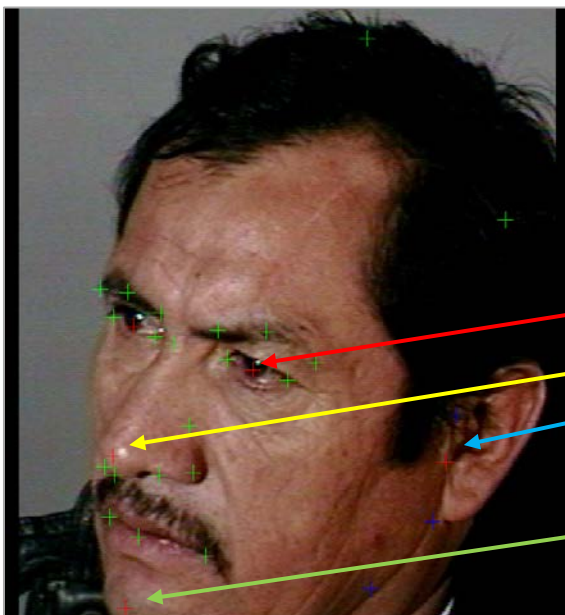


Figure 11

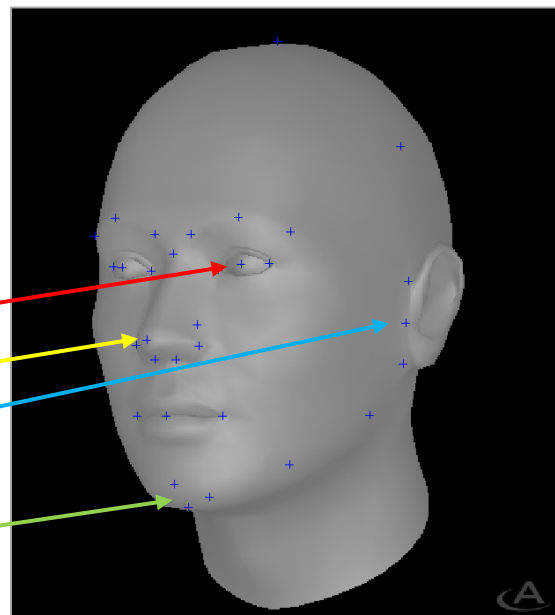


Figure 12

The 3D pose correction software now renders a better facial image, which can be positioned into a frontal facial image.

Figure 13 is an example without 'symmetric filling' the 3D pose correction.



Figure 13

The symmetric filling option uses features on the subject's (visible) left side of the face to fill in on the subject's right side (not visible):

- The creases on the forehead
- The character of the eyebrows
- The wrinkles around the eyes
- The ears
- The hairline

This reinforces the need to always use the original imagery for any 1:1 comparisons of the candidates returned from a search.



Figure 14: An example of a symmetrically filled image

The symmetrically filled image (Figure 14) can now be positioned to the full frontal facial image (Figure 15).

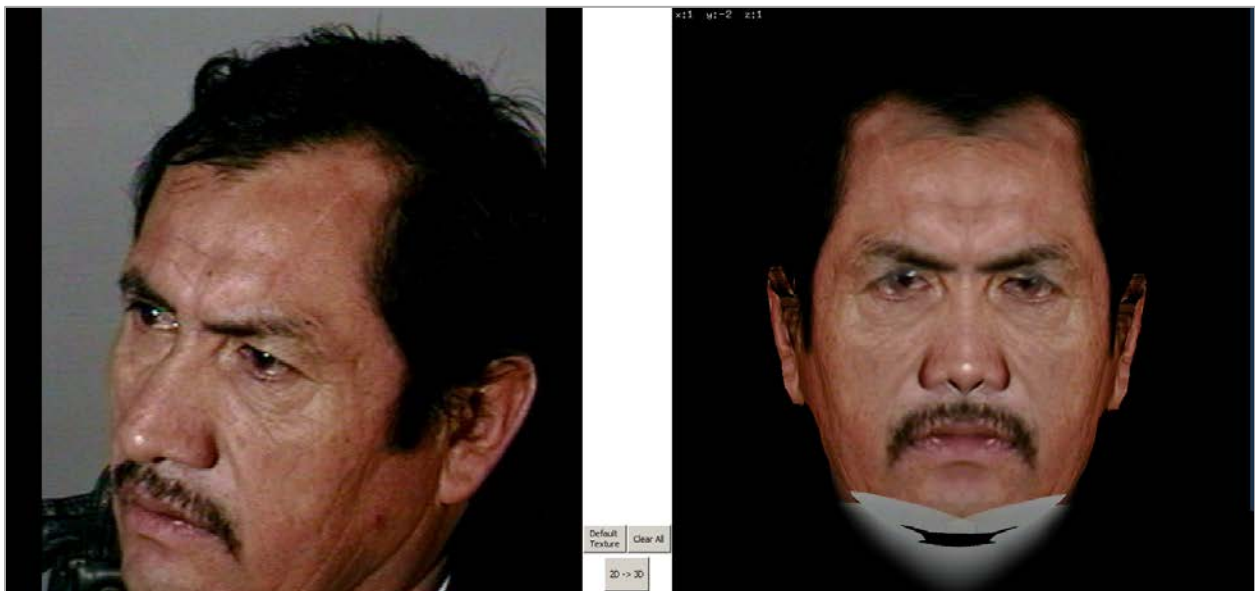


Figure 15

Some 3D pose correction software products offer tools such as 'wire mask', where multiple landmarks are presented overlaying the imagery. This can be used to verify a correct overlay from the angled pose to the 3D pose corrected image. See Figure 16-17 as an example.



Figure 16

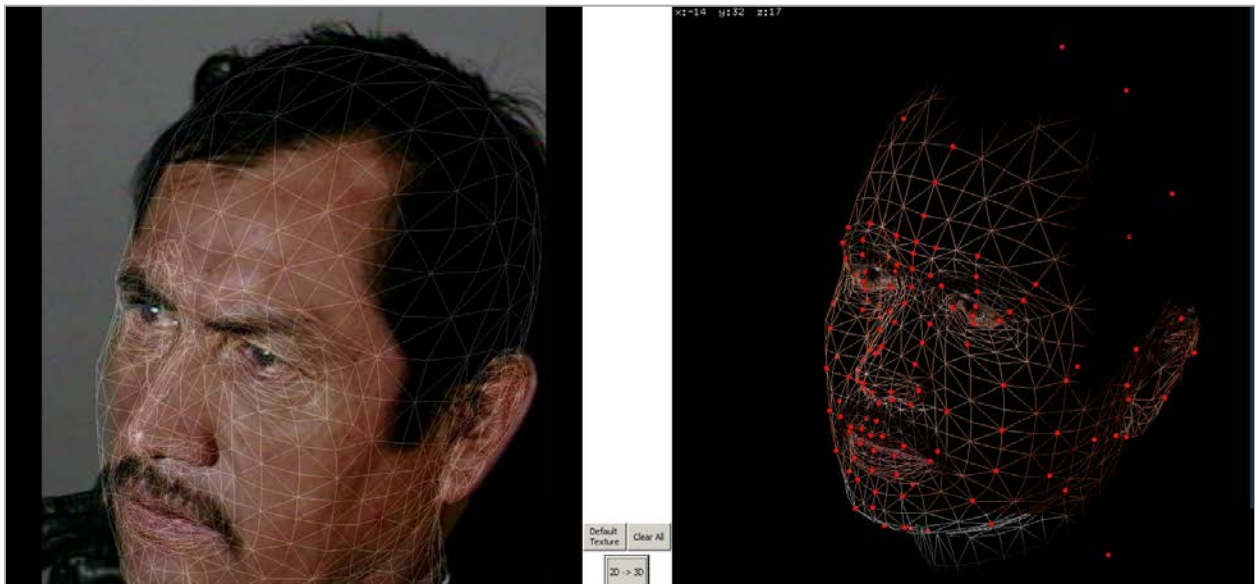


Figure 17

This may enable further refinements of the facial landmarks to better fit the 3D pose correction model.

4. Export the front facing pose corrected images to be used as search probes. Note that 3D pose correction software can also export a full range of pose variations. See Figure 18 as example pose variations.



Figure 18

Note the differences and similarities between the actual photo of the subject (Figure 19) and the export from 3D pose correction software (Figure 20).

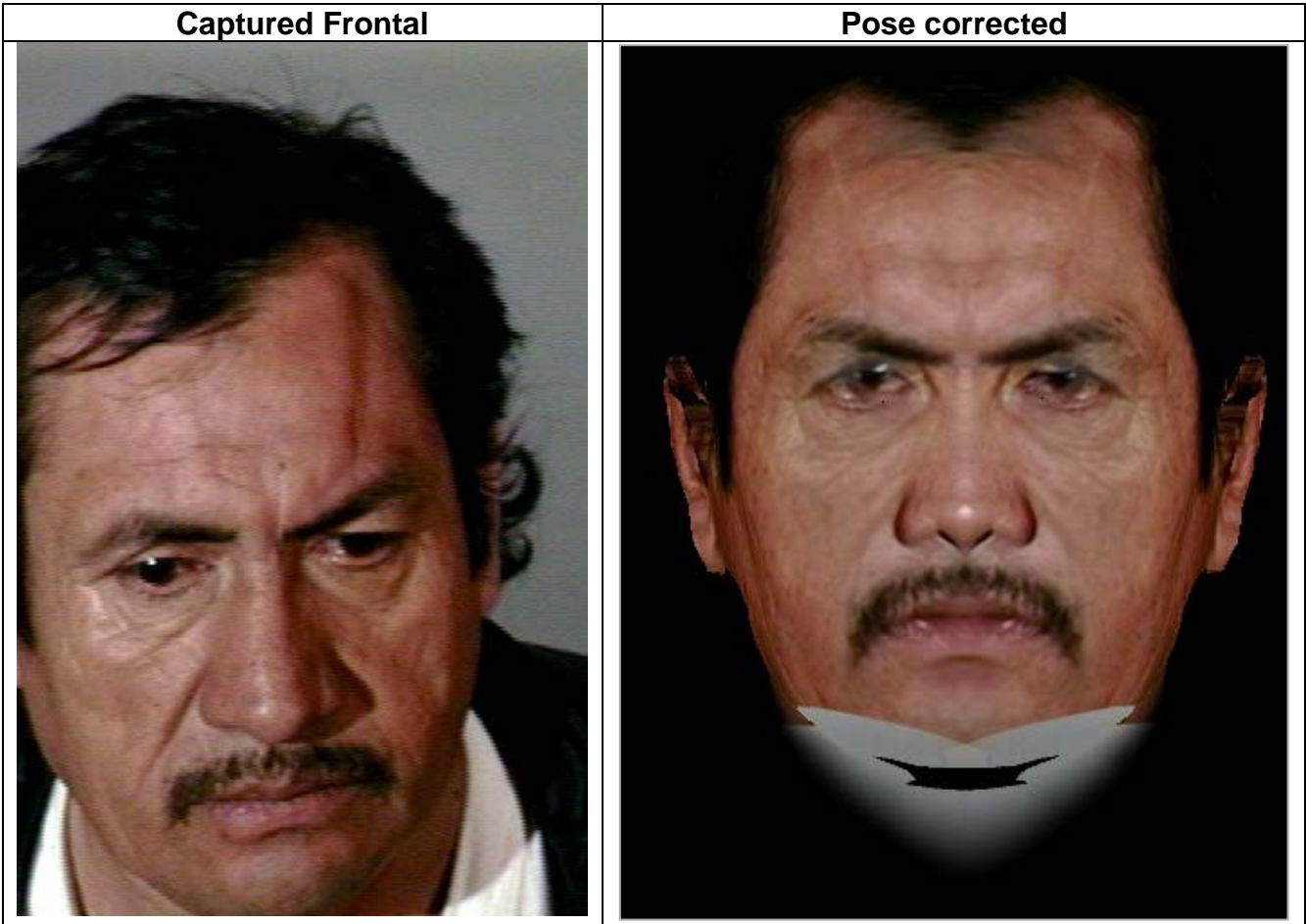


Figure 19

Figure 20

Single Image Pose Correction: Profile Subject Pose

The 3D pose correction process can also be carried out from a profile image such as below (Figure 21).



Figure 21

1. Load the image into the 3D pose correction software. In this example the assumed pose is presented for selection (Figure 22). This will then select the proper model accordingly.

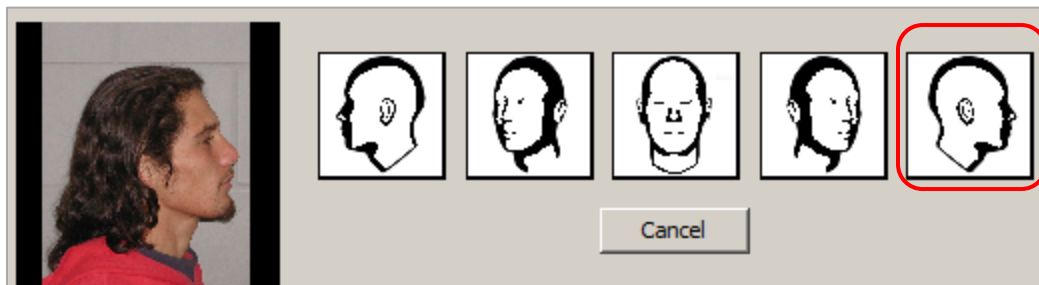


Figure 22

2. The software will then perform its initial face finding and attempt to locate the correct facial landmarks aligned to the model. In this example the facial landmarks are located correctly (Figure 23).



Figure 23

After the facial landmarks are identified, the software will generate the 3D model (Figure 24).



Figure 24

The 3D pose correction software in this document allows a wire mask to be presented overlaying the imagery. This can be used to verify a correct overlay from the profile pose to the 3D pose corrected image (Figure 25).

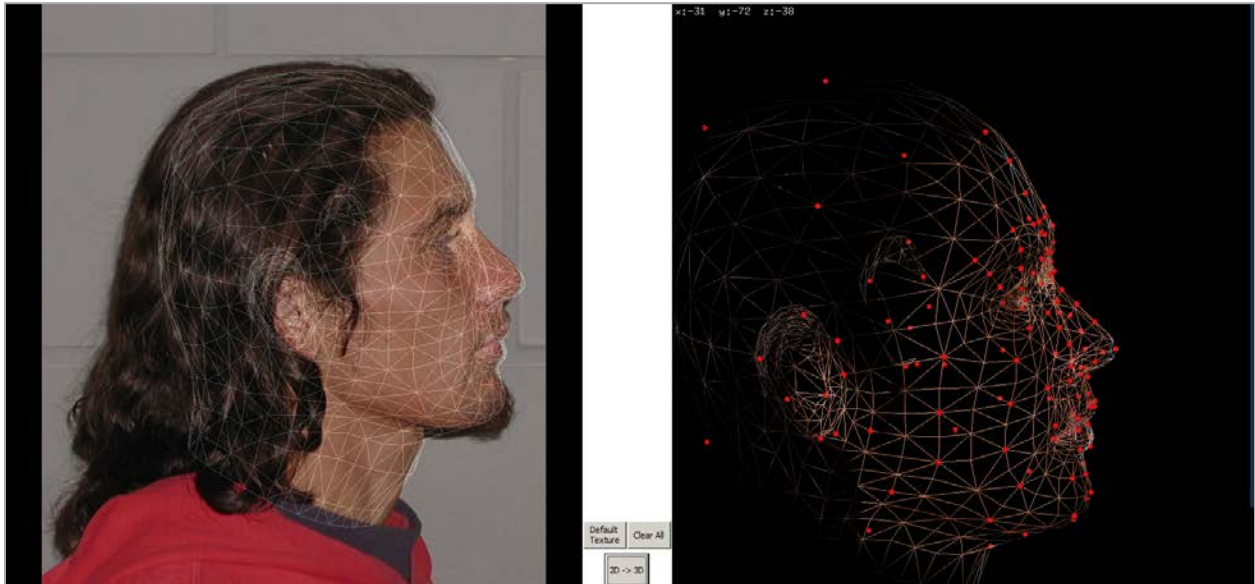


Figure 25

This may enable further refinements of the facial landmarks to better fit the 3D pose correction model.

The symmetrically filled image can now be positioned to the full frontal facial image (Figure 26).



Figure 26

Comparing the unprocessed frontal image to the pose corrected image is shown below (Figure 27). Things to note on this specific example:

- The symmetric filling options used features on the subject's (visible) left side of the face to fill in on the subject's right side (not visible):
 - The facial hair
 - The eyebrows
 - The hairline
 - The facial marks on the forehead and cheeks

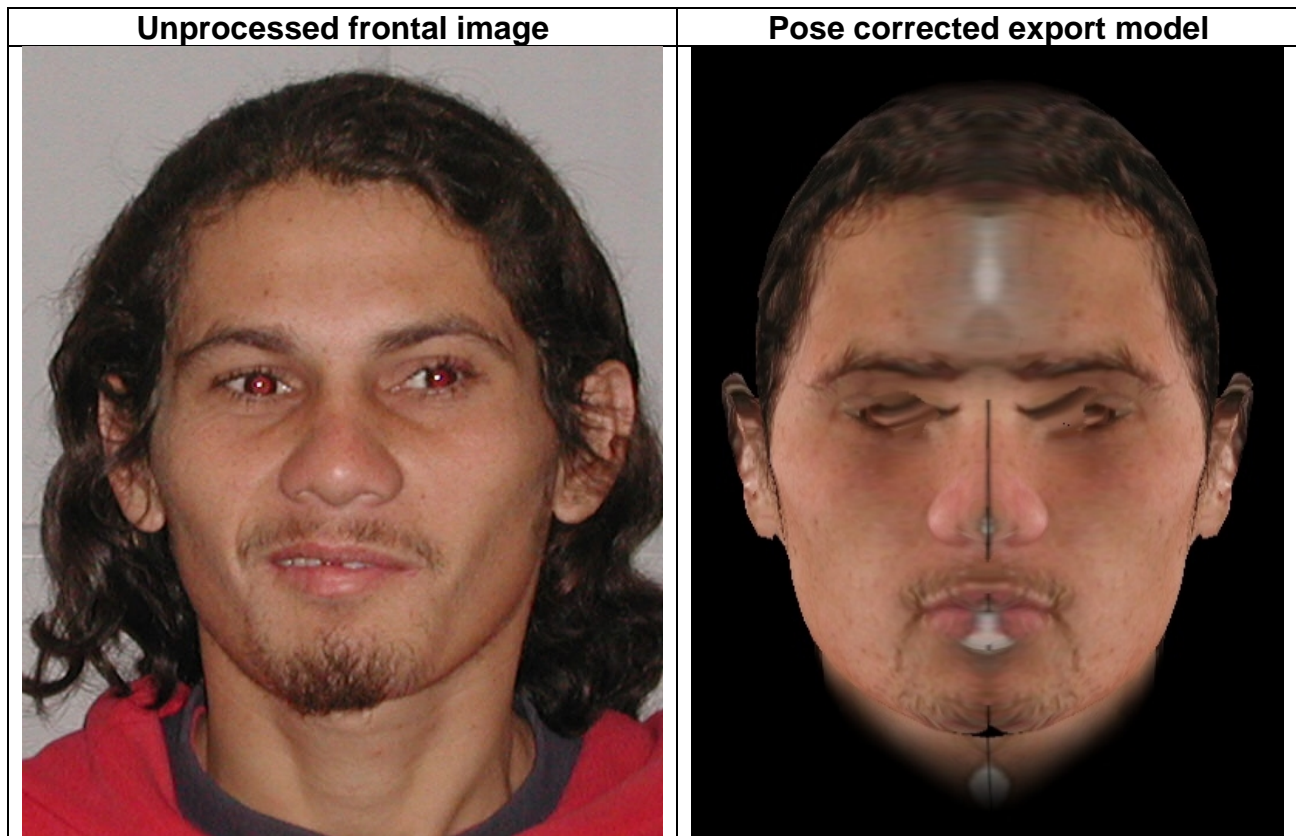


Figure 27

In summary, the techniques outlined in this document are intended to be used to provide potential leads that may result from the candidate search result set.

Reference List

FISWG documents can be found at: www.FISWG.org

ANSI/NIST-ITL Standard Homepage: http://www.nist.gov/itl/iad/ig/ansi_standard.cfm