



Visage Technologies
FACE TRACKING & ANALYSIS

VisageTracker Configuration Manual

version 8.1

Visage Technologies AB

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1. Introduction

This manual is meant for users who wish to take advantage of advanced functionalities that can be obtained from the tracker using custom configuration files.

The tracker is fully configurable through an extensive set of parameters in easily manageable configuration files. Each configuration file fully defines the tracker operation, in effect customizing the tracker for a particular application.

The configuration file is loaded every time the new tracking session is started by calling the `VisageTracker::track()` function. It is possible to change the configuration file between tracking sessions using `VisageTracker::setTrackerConfigurationFile()`.

Furthermore, the configuration files in the same format are also used for facial features detection though in this case only a subset of configuration parameters is used. At the moment, `Face Detector.cfg` is used and it is not possible to change configuration name for facial features detection.

1.1. Standard configuration files

visage|SDK comes with several standard configuration files aimed at common usage scenarios. Table 1. provides an overview of all available configurations.

Table 1. Standard configuration files

| Configuration file name | Overview |
|------------------------------------|--|
| Head Tracker.cfg | Optimized for high performance head pose tracking. |
| Facial Features Tracker - High.cfg | Facial features tracker optimized for real time operation from camera or video files on high performance mobile devices such as iPhone6 as well as all desktop/laptop computers. Tracks head pose, mouth, eyebrows and eye motion. |
| Facial Features Tracker - Low.cfg | Facial features tracker optimized for real time operation from camera or video files on low performance mobile devices such as iPhone4S. Tracks head pose, mouth, eyebrows and eye motion. |
| Face Detector.cfg | Used in face detection. |

2. Customizing the tracker

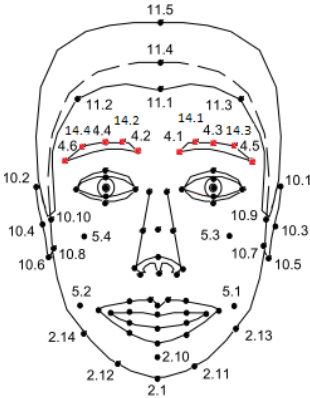
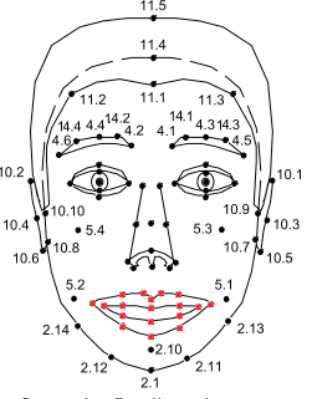
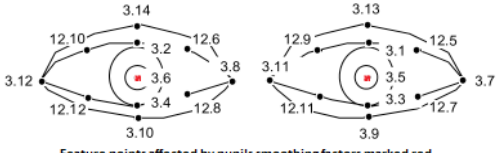
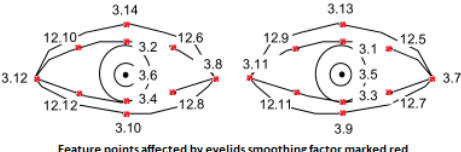
Information in this chapter allows users to create own application-specific tracker configurations.

2.1. Configuration parameters

The following table provides the detailed description of parameters defined in the configuration file and their usage. Some parameters are available only on specific platform marked in table as "WIN" for Windows, "IOS" for iOS, "AND" for Android, "MAC" for MAC OS X, "LIN" for Linux and "HTML5" for HTML5.

Table 2. Configuration parameters

| Parameter name | Description |
|---|---|
| Parameters controlling tracker initialization and recovery | |
| min_face_scale [WIN, IOS, AND, MAC, HTML5, LIN] | This value controls the lower limit for face scale search range used during initialization and recovery. It is defined as decimal fraction [0.0 - 1.0] of the input image size, where image size is defined as smaller of the image's width and height. For example, if min_face_scale is set to 0.1 and image dimensions are 800x600, smallest face that will be searched for will be $0.1 \times \min(800, 600) = 60\text{px}$. |
| max_face_scale [WIN, IOS, AND, MAC, HTML5, LIN] | This value controls the upper limit of face scale search range used during initialization and recovery. It is defined as decimal fraction [0.0 - 1.0] of the input image size, where image size is defined as smaller of the image's width and height. For example, if max_face_scale is set to 0.8 and image dimensions are 800x600, largest face that will be searched for will be $0.8 \times \min(800, 600) = 480\text{px}$. |
| recovery_timeout [WIN, IOS, AND, MAC, HTML5, LIN] | This value is used when the tracker loses the face and cannot detect any face in the frame. This value tells the tracker how long it should wait before considering that the current user is gone and initializing the full re-initialization procedure. If the face is detected before this time elapses, the tracker considers that it is the same person and recovers, i.e. continues tracking it using the previous settings. The time is expressed in milliseconds. |
| Parameters controlling the smoothing filter | |
| smoothing_factors [WIN, IOS, AND, MAC, HTML5, LIN] | <p>The tracker can apply a smoothing filter to the tracking results to reduce the inevitable tracking noise. An adaptive smoothing filter is used, maximizing stability when the face is still while reducing delay when the face moves. Still, smoothing inevitably introduces some delay so it should be used sparingly.</p> <p>The value 0 provides maximal smoothing and lowest response (longest delay). Higher values provide less smoothing but higher response. The value of -1 disables smoothing completely for specific group.</p> <p>Smoothing is applied only on the detected feature points (2D points) but it also affects the 3D data indirectly.</p> <p>Smoothing factors are set separately for the following groups of tracking results, one factor value for each group:</p> <p>Eyebrows: Applies smoothing to parameters that represent eyebrow movement. The following members of FaceData::featurePoints2D are directly affected by this factor: group 4, feature points 1 to 6; group 14, feature points 1 to 4.</p> |

| Parameter name | Description |
|----------------|---|
| |  <p>Feature points affected by eyebrows smoothing factor marked red</p> <p>Mouth: Applies smoothing to parameters that represent mouth movement. The following members of FaceData::featurePoints2D are directly affected by this factor: group 2, feature points 2 to 9; group 8, feature points 1 to 10.</p>  <p>Feature points affected by mouth smoothing factor marked red</p> <p>Pupils: Applies smoothing to parameters that represent pupil movement (indirectly affects the responsiveness of gaze direction estimation). The following members of FaceData::featurePoints2D are directly affected by this factor: group 3, feature points 5 and 6.</p>  <p>Feature points affected by pupils smoothing factors marked red</p> <p>Eyelids: Applies smoothing to parameters that represent eyelid region movement (indirectly affects responsiveness of eye closure estimation). The following members of FaceData::featurePoints2D are directly affected by this factor: group 3, all feature points except 5 and 6 (pupils); group 12, feature points 5 to 12.</p>  <p>Feature points affected by eyelids smoothing factor marked red</p> |

| Parameter name | Description |
|---|--|
| Parameters related to the 3D models used Because the tracker and detector yield only 2D points, visage SDK uses 3D facial models to estimate the 3D information such as head pose, 3D facial points, Action Units or full 3D facial mesh. Depending on application requirements, up to three different models may be used: one for head pose estimation, one for Action Units estimation and one for 3D mesh fitting.. For performance/data size/memory footprint reasons, it is recommended to use only the models corresponding to the functionality required by the application - for example, if the application requires only 3D head pose but not the 3D mesh nor action units, use only one model and disable others (note that it is possible to disable Action Units and 3D model fitting within the application – see VisageTracker::setTrackerConfiguration). Furthermore, models can be customized or completely replaced by custom-built ones if so required by specific applications - see section 2.3 for details. The following parameters are used to specify which models are used. | |
| pose_fitting_model [WIN, IOS, AND, MAC, LIN] | File name of the 3D model used to estimate the 3D head pose (returned in FaceData::faceTranslation and FaceData::faceRotation). This model is required for the functioning of the tracker and should not be disabled; it is recommended to use the default one as set in the tracking configurations shipped in visage SDK. The file name may contain a path, and it must be relative to the location of the configuration file. In face detector configurations, it is possible to disable this model by setting this parameter to "none" or simply removing it from the configuration; this will yield a small gain in data size, memory footprint and performance. NOTE: HTML5 version does not support relative paths. Provide only name of model file (e.g. jk_300.wfm). |
| pose_fitting_fdp [WIN, IOS, AND, MAC, LIN] | Name of the MPEG-4 feature Points Definition (FDP) file corresponding to the 3D model file specified by the pose_fitting_model parameter. The file name may contain a path, and it must be relative to the location of the configuration file. For more details, please refer to the section on the 3D Model. NOTE: HTML5 version does not support relative paths. Provide only name of model file (e.g. jk_300.fdp). |
| pose_fitting_au_use [WIN, IOS, AND, MAC, LIN] | Indicates which Action Units from the 3D model file specified by the pose_fitting_model parameter are actually active in tracking; the ones set to 1 are active and the ones set to 0 are not used. The comment line after the numbers is included for easier identification of Action Units. |
| pose_fitting_su_use [WIN, IOS, AND, MAC, LIN] | Indicates which Shape Units from the 3D model file specified by the pose_fitting_model parameter are actually active in tracking; the ones set to 1 are active and the ones set to 0 are not used. |
| pose_fitting_pose_sensitivity [WIN, IOS, AND, MAC, LIN] | Sensitivity values for rotation (3 values) and translation (3 values) for the 3D model file specified by the pose_fitting_model parameter. A higher value results in faster reaction of the tracker but also more sensitivity to noise. The comment line after the numbers is included for easier identification of the pose parameters. |
| pose_fitting_au_sensitivity [WIN, IOS, AND, MAC, LIN] | Sensitivity values for Action Units (one for each AU) for the 3D model file specified by the pose_fitting_model parameter. A higher value results in faster reaction of the tracker but also more sensitivity to noise. The comment line after the numbers is included for easier identification of Action Units. For further details please refer to the section on Action Units and to the section on the 3D Model. |
| pose_fitting_su_sensitivity [WIN, IOS, AND, MAC, LIN] | Sensitivity values for Shape Units for the 3D model file specified by the pose_fitting_model parameter. A higher value results in faster reaction of the tracker but also more sensitivity to noise. |
| au_fitting_model [WIN, IOS, AND, MAC, LIN] | File name of the 3D model used to estimate the Action Units (returned in FaceData::faceTranslation and FaceData::faceRotation); for more details on Action Units, their customization, and the 3D models in general, please refer to the section on the 3D Model. If Action Units are not required by an application, it is recommended to disable this function by setting this parameter to "none" or simply removing it from the configuration; this will yield a small gain in data size, memory footprint and performance. NOTE: HTML5 version does not support relative paths. Provide only name of model file (e.g. candide3.wfm). |
| au_fitting_fdp | Name of the MPEG-4 feature Points Definition (FDP) file corresponding to the 3D |

| Parameter name | Description |
|---|---|
| [WIN, IOS, AND, MAC, HTML5, LIN] | model file specified by the au_fitting_model parameter. The file name may contain a path, and it must be relative to the location of the configuration file. For more details, please refer to the section on the 3D Model. NOTE: HTML5 version does not support relative paths. Provide only name of model file. (e.g. candide3.fdp). |
| au_fitting_au_use [WIN, IOS, AND, MAC, HTML5, LIN] | Indicates which Action Units from the 3D model file specified by the au_fitting_model parameter are actually active in tracking; the ones set to 1 are active and the ones set to 0 are not used. The comment line after the numbers is included for easier identification of Action Units. For further details please refer to the section on Action Units and to the section on the 3D Model. |
| au_fitting_su_use [WIN, IOS, AND, MAC, HTML5, LIN] | Indicates which Shape Units from the 3D model file specified by the au_fitting_model parameter are actually active in tracking; the ones set to 1 are active and the ones set to 0 are not used. |
| au_fitting_au_sensitivity [WIN, IOS, AND, MAC, HTML5, LIN] | Sensitivity values for Action Units (one for each AU) for the 3D model file specified by the au_fitting_model parameter. A higher value results in faster reaction of the tracker but also more sensitivity to noise. The comment line after the numbers is included for easier identification of Action Units. For further details please refer to the section on Action Units and to the section on the 3D Model. |
| au_fitting_su_sensitivity [WIN, IOS, AND, MAC, HTML5, LIN] | Sensitivity values for Shape Units for the 3D model file specified by the au_fitting_model parameter. A higher value results in faster reaction of the tracker but also more sensitivity to noise. |
| au_names [WIN, IOS, AND, MAC, HTML5, LIN] | Contains list of action units names. Exclusive to the au_fitting_model. |
| | |
| mesh_fitting_model [WIN, IOS, AND, MAC, HTML5, LIN] | File name of the 3D model used to fit a fine 3D mesh to the face (returned in FaceData::faceTranslation and FaceData::faceRotation); for more details on 3D models and their customization, please refer to the section on the 3D Model. If an application does not require the fine 3D facial mesh, it is recommended to disable this function by setting this parameter to "none" or simply removing it from the configuration; this will yield a small gain in data size, memory footprint and performance. NOTE: HTML5 version does not support relative paths. Provide only name of model file. (e.g. candide3.wfm). |
| mesh_fitting_fdp [WIN, IOS, AND, MAC, HTML5, LIN] | Name of the MPEG-4 feature Points Definition (FDP) file corresponding to the 3D model file specified by the mesh_fitting_model parameter. The file name may contain a path, and it must be relative to the location of the configuration file. For more details, please refer to the section on the 3D Model. NOTE: HTML5 version does not support relative paths. Provide only name of model file. (e.g. candide3.fdp). |
| mesh_fitting_au_use [WIN, IOS, AND, MAC, HTML5, LIN] | Indicates which Action Units from the 3D model file specified by the mesh_fitting_model parameter are actually active in tracking; the ones set to 1 are active and the ones set to 0 are not used. The comment line after the numbers is included for easier identification of Action Units. |
| mesh_fitting_su_use [WIN, IOS, AND, MAC, HTML5, LIN] | Indicates which Shape Units from the 3D model file specified by the mesh_fitting_model parameter are actually active in tracking; the ones set to 1 are active and the ones set to 0 are not used. |
| mesh_fitting_au_sensitivity [WIN, IOS, AND, MAC, HTML5, LIN] | Sensitivity values for Action Units (one for each AU) for the 3D model file specified by the mesh_fitting_model parameter. A higher value results in faster reaction of the tracker but also more sensitivity to noise. The comment line after the numbers is included for easier identification of Action Units. For further details please refer to the section on Action Units and to the section on the 3D Model. |
| mesh_fitting_su_sensitivity [WIN, IOS, AND, MAC, HTML5, LIN] | Sensitivity values for Shape Units for the 3D model file specified by the mesh_fitting_model parameter. A higher value results in faster reaction of the tracker but also more sensitivity to noise. |
| Parameter controlling the processing of eyes. | |

| Parameter name | Description |
|---|---|
| process_eyes [WIN, IOS, AND, MAC, HTML5, LIN] | Bit-flag parameter that controls gaze vector calculation and pupil points refinement. If the parameter is set to 0, both functionalities will be disabled. First bit controls the gaze calculations and second bit controls the pupil point refinement, so setting the parameter to 1 enables the gaze calculations, setting it to 2 enables the pupil refinement and setting it to 3 enables both functionalities. Both functionalities are enabled by default (process_eyes 3). |
| Precision/performance trade-off parameters Other than the parameters listed here, there are a few more parameters that affect performance – please see section 2.2.1. | |
| lbf_stage_modifier [WIN, IOS, AND, MAC, HTML5, LIN] | Reduces total number of stages by this value. Default value is 0. There is maximum 5 stages. For example, setting the value to 1 will skip the final stage during detection, 2 will skip 2 final stages, etc. Increasing the value of this parameter increases performance but reduces feature points precision. |
| lbf_nperturb [WIN, IOS, AND, MAC, HTML5, LIN] | Number of perturbations for each feature points detection. Default value is 4. Reducing the number of perturbation increases performance but reduces feature points precision. |
| tracking_preproc [WIN, IOS, AND, MAC, HTML5, LIN] | Indicates whether additional preprocessing of input image will be used for tracking algorithms. If set to 1, it increases accuracy, but decreases performance. |
| Limits (min, max) on tracker outputs. When any of the results goes out of the specified range, full or partial re-initialisation is initiated. | |
| rotation_limit [WIN, IOS, AND, MAC, HTML5, LIN] | Limit values for the rotations around the x, y and z axis. |
| translation_limit [WIN, IOS, AND, MAC, HTML5, LIN] | Limit values for the translations in x, y, and z directions. |
| action_unit_limit [WIN, IOS, AND, MAC, HTML5, LIN] | Limit values for action units. Please refer to the section on Action Units for further details regarding Action Units. |

2.2. General configuration and setup guidelines

These general guidelines may help to obtain optimal tracking results:

- Determine *camera_focus* parameter (see).
- The room and the face should be well lit. User can experiment with different types of lighting (indirect daylight is usually the best, neon lights the worst).
- User should disable automatic adjustment of the camera settings by the driver like gain, exposure, white balance and similar and set them manually, if possible, depending on the camera used and lighting conditions.

2.2.1. Optimizing tracking performance

This section summarizes the configuration parameters that most affect the tracking performance.

Table 3. Parameters effect on performance

| PARAMETERS | EFFECT ON PERFORMANCE |
|--------------------|---|
| lbf_stage_modifier | Increasing this parameter decreases performance but may improves accuracy. |
| lbf_nperturb | Increasing this parameter decreases performance but also reduces tracking noise. |
| tracking_preproc | If set to 1, it increases accuracy, but decreases performance. |
| process_eyes | Disabling this increases performance, but reduces pupil points detection accuracy and disables gaze vector calculation. |
| au_model | Disabling this increases performance. |
| mesh_model | Disabling this increases performance. |

A detailed explanation of the parameters can be found in the section 2.1.

Other than these parameters, the resolution of input image also affects performance.

2.2.2. Estimating the camera focus

The *camera_focus* parameter can be roughly estimated in the following way:

1. Start the application and tracking from camera.
2. Take an object of known length (e.g. rope, stick or ruler) and place it perpendicular to the camera so that its length fills the smaller dimension of the camera image (e.g. height for landscape image).
3. Measure the distance from the object to the camera.
4. Calculate the camera focus value by dividing the measured distance with the length of the object and multiplying it with 2.

2.2.3. Configuration and data files

Other than the configuration files (.cfg), the tracker requires several other data files some of them also user-customizable, these files are defined in the configuration file.

The following example shows one possible file structure for a tracking application on Windows and relevant path settings in config file.

File structure:

```
(...)\TrackerApp\Resources\Facial Features Tracker – High.cfg  
(...)\TrackerApp\Resources\Facial Features Tracker - Low.cfg  
(...)\TrackerApp\Resources\candide3.wfm  
(...)\TrackerApp\Resources\candide3.fdp  
(...)\TrackerApp\Resources\jk_300.wfm  
(...)\TrackerApp\Resources\jk_300.fdp  
(...)\TrackerApp\Resources\bdtsdata\FF\ff.dat  
(...)\TrackerApp\Resources\bdtsdata\LBF\pe\  
(...)\TrackerApp\Resources\bdtsdata\LBF\vfadata\  
(...)\TrackerApp\Resources\bdtsdata\NN\
```

Config file settings:

```
...  
au_fitting_model candide3.wfm  
au_fitting_fdp candide3.fdp  
bdts_data_path bdtsdata  
...
```

Tracker initialized with:

Assumes that the current working folder is (...)\TrackerApp

```
tracker = new VisageSDK::VisageTracker2("Facial Features Tracker - High .cfg");
```

Similar folder structures are possible on other operating systems.

2.3. The 3D models used in tracking

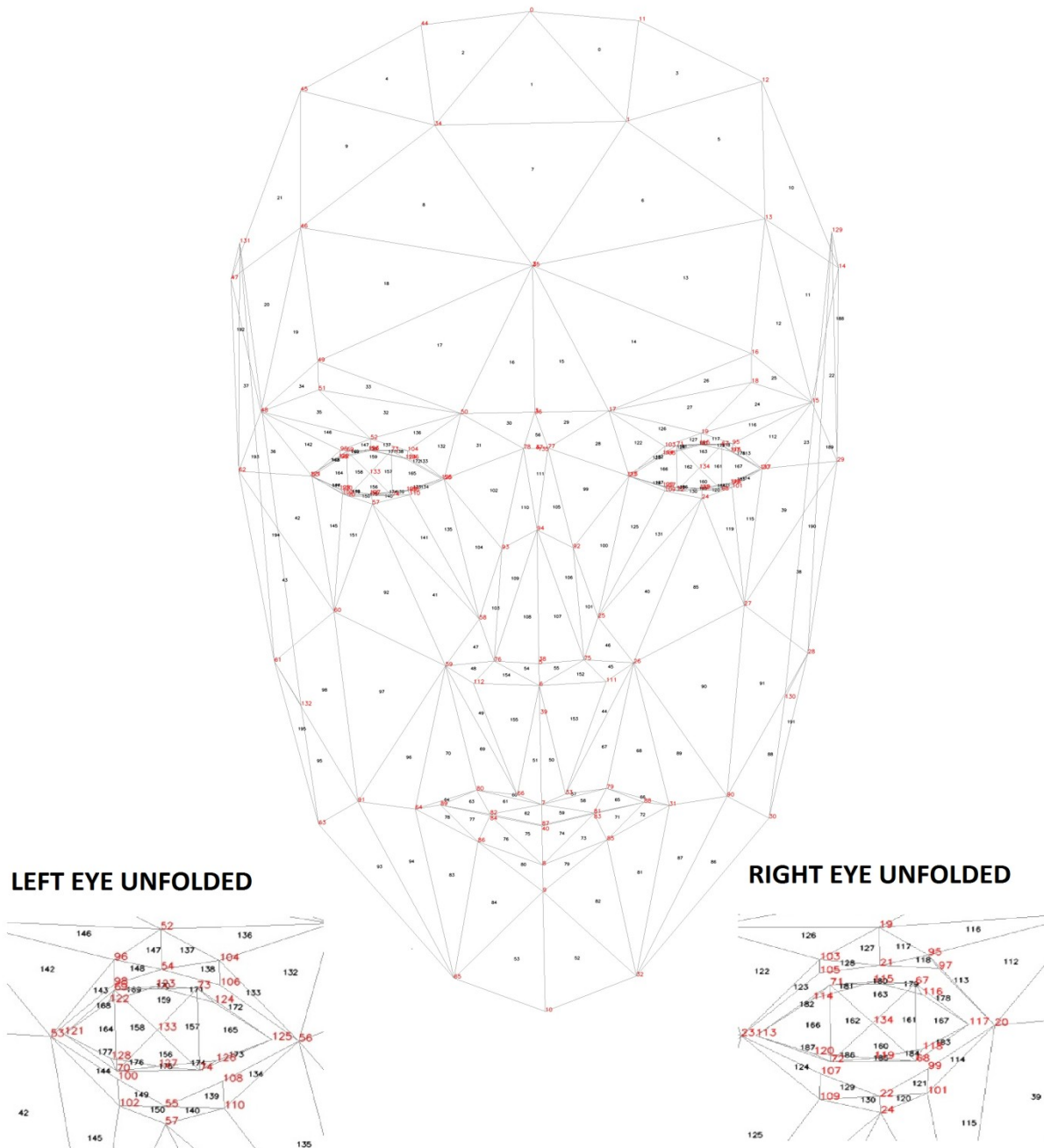
As explained in section 2.1., tracker and detector can use up to three different 3D model files for estimating 3D information by fitting the 3D face model to detected/tracked 2D feature points in the image. The 3D models are written in a simple, documented text file format so they can be fully configured or custom models used for any specific requirements.

This section briefly describes the default models shipped with visage|SDK, and specifies the file formats used in order to enable customization.

2.3.1. The Candidate model

This model is currently used to evaluate action units and shape units (au_fitting_model in section 2.1.). It is planned to replace candidate with a more detailed/accurate model in one of the upcoming releases.

The model is defined in the file candidate3.wfm, consists of 157 vertices forming 228 faces. An alternative model, candidate3-ClosedMouth.wfm is available for special purposes, when closed mouth is required.



2.3.2. The jk_300 model

This model is used to estimate pose and provide fine mesh of the face. The model consist of 357 vertices and 640 triangles.

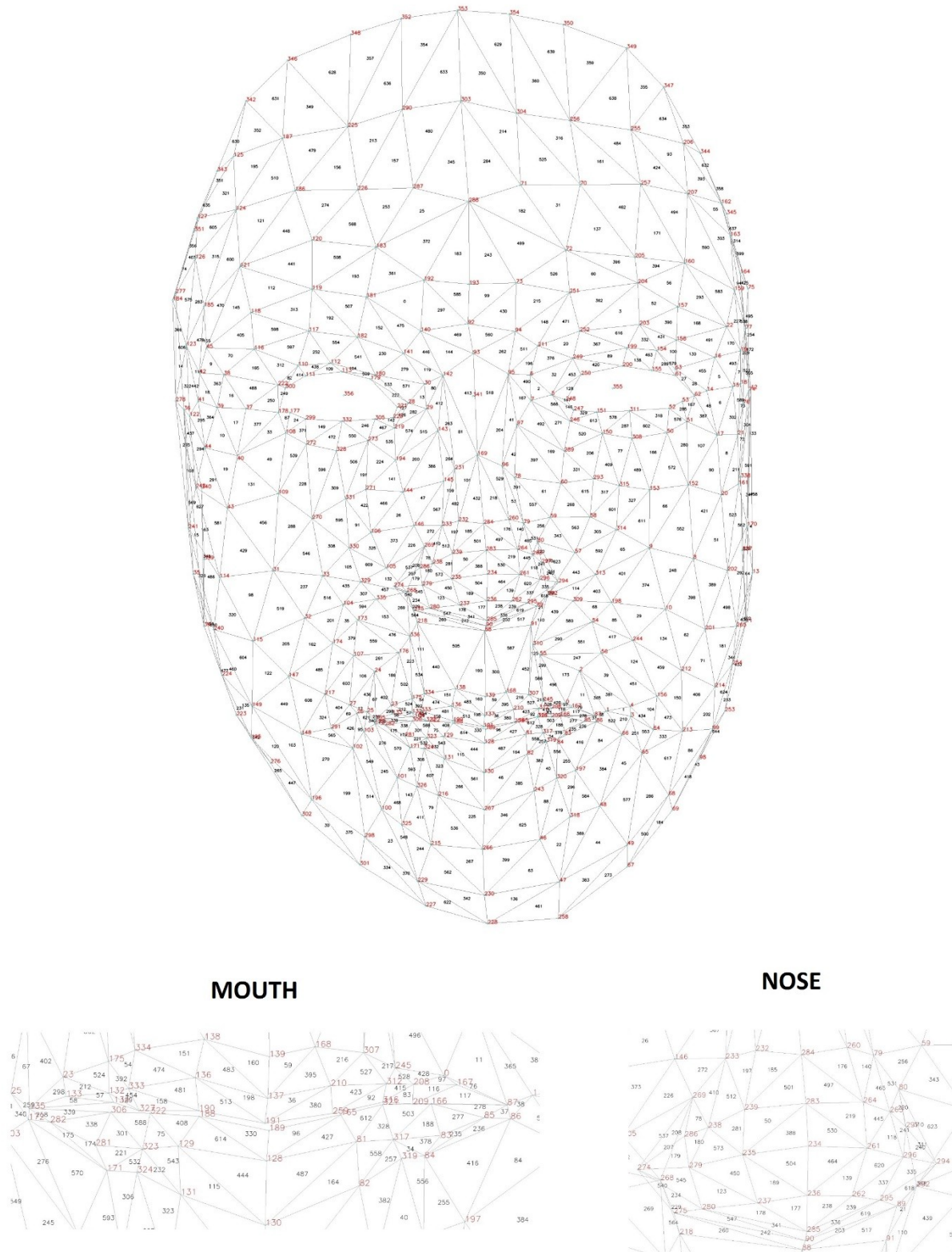


Figure 2. jk_300 model

2.3.3. File formats for 3D models

It is possible to modify this file or to configure the tracker to use a different 3D model file. The 3D model has a number of Action Units defined for animating the model, and a number of Shape Units for deforming the initial model shape.

The 3D models are written in plain text .wfm file format, specified as follows (lines beginning with # are comments):

```
# VERTEX LIST:
[vertex count]
[x y z] (vertex coordinates)
...
[x y z] (vertex coordinates)

# FACE LIST:
[face count]
[i1 i2 i3] (vertex indices making a face)
...
[i1 i2 i3] (vertex indices making a face)

# ANIMATION UNITS LIST:
[action units count]

# action unit description
[number of affected vertices]
[vertex_index x_offset y_offset z_offset]
...
[vertex_index x_offset y_offset z_offset]

...

# action unit description
[number of affected vertices]
[vertex_index x_offset y_offset z_offset]
...
[vertex_index x_offset y_offset z_offset]

# SHAPE UNITS LIST:
[shape units count]

# shape unit description
[number of affected vertices]
[vertex_index x_offset y_offset z_offset]
...
[vertex_index x_offset y_offset z_offset]

...

# shape unit description
[number of affected vertices]
[vertex_index x_offset y_offset z_offset]
...
[vertex_index x_offset y_offset z_offset]

# END OF FILE
```

Related to the 3D model file is the FDP file. This simple file contains the correspondences between the standard MPEG-4 Facial Feature Points with some non-standard extensions and the vertices of the face model. For details regarding the MPEG-4 Feature Points, including a schematic view of all feature point numbers, see the MPEG-4 Face and Body Animation Introduction.

The FDP file format consists of one line of text for each feature point, in the following format:

```
<group>.<index><x><y><z><mesh_index>.<vertex_index>.
```

The information used by the tracker is the MPEG-4 group and index, and the corresponding vertex index - the index of the feature point's vertex in the 3D model.

2.4. Action Units

The action units returned by the tracker, and referred to in the configuration parameters documentation, are defined in the 3D face model file (see previous section). Action Units can be modified by the user by editing or replacing the 3D face model file specified by the `au_fitting_model` configuration parameter.

Furthermore, the tracker configuration file defines the names for action units (see `au_names` parameter). These names are returned as tracking results together with action unit values - see documentation of `VisageSDK::FaceData` structure for further details. The actual actions units used in the standard configurations are shown in Table 4.

Possible use of action units include facial animation, or facial analysis; for example, it would be possible to define FACS action units in order to obtain automatic FACS scoring.

Table 4. Actions units used by standard configurations

| Action Units | |
|---|---|
| AU1: Nose wrinkler | AU13: Left eye closed (AU42/43/44/45) |
| AU2: Jaw z-push (NOT ACTIVE) | AU14: Lid tightener (AU7) (NOT ACTIVE) |
| AU3: Jaw x-push | AU15: Upper lid raiser (AU5) (NOT ACTIVE) |
| AU4: Jaw drop | AU16: Rotate eyes left |
| AU5: Lower lip drop | AU17: Rotate eyes down |
| AU6: Upper lip raiser (AU10) | AU18: Lower lip x-push |
| AU7: Lip stretcher left (AU20) | AU19: Lip stretcher right |
| AU8: Lip corner depressor (AU13/15) | AU20: Right outer brow raiser |
| AU9: Lip presser (AU23/24) (NOT ACTIVE) | AU21: Right inner brow raiser |
| AU10: Left outer brow raiser | AU22: Right brow lowerer |
| AU11: Left inner brows raiser | AU23: Right eye closed |
| AU12: Left brow lowerer | |