Face identification for stand-alone or Web solutions

VeriLook SDK
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Face identification for stand-alone or Web applications

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VeriLook facial identification technology is designed for biometric systems developers and integrators. The technology assures system performance and reliability with live face detection, simultaneous multiple face recognition and fast face matching in 1-to-1 and 1-to-many modes.

VeriLook is available as a software development kit that allows development of stand-alone and Web-based solutions on Microsoft Windows, Linux, Mac OS X, iOS and Android platforms.

- Millions of algorithm deployments worldwide over the past 14 years.
- Live face detection prevents cheating with a photo in front of a camera.
- Simultaneous multiple face processing in live video and still images.
- Gender recognition and facial feature points extraction for each person in an image.
- Near-infrared and visible light spectrum facial images can be matched against each other.
- Webcams or other low cost cameras are suitable for obtaining face images.
- Available as multiplatform SDK that supports multiple programming languages.
- Face Verification SDK is available for developing large-scale high-security apps.
- Reasonable prices, flexible licensing and free customer support.
VeriLook algorithm features and capabilities

Performance numbers are provided for a PC with Intel Core 2 Q9400 processor (2.67 GHz).

The VeriLook algorithm implements advanced face localization, enrollment and matching using robust digital image processing algorithms, which are based on deep neural networks:

- **Simultaneous multiple face processing.** VeriLook 10.0 performs fast and accurate detection of multiple faces in live video streams and still images. All faces on the current frame are detected in **0.01 - 0.86 seconds** depending on selected values for face roll and yaw tolerances, and face detection accuracy. After detection, a set of features is **extracted** from each face into a template in 0.6 seconds. See technical specifications for more details.

- **Gender classification.** Optionally, gender can be determined for each person on the image with predefined degree of accuracy during the template extraction.

- **Live face detection.** A conventional face identification system can be tricked by placing a photo in front of the camera. VeriLook is able to prevent this kind of security breach by determining whether a face in a video stream is “live” or a photograph. See recommendations for live face detection in the chapters below for more details.

- **Emotions recognition.** VeriLook can be configured to recognize emotion type in a human face. Six basic emotions are analyzed: anger, disgust, fear, happiness, sadness and surprise. A confidence value for each of the basic emotions is returned for the face. Larger value for an emotion means that it seems to be more expressed in the face.

- **Facial feature points.** The points can be optionally extracted as a set of their coordinates during face template extraction. Each of the **68 points** has a fixed sequence number (i.e. number 31 always corresponds to nose tip).

- **Facial attributes.** VeriLook can be configured to detect certain attributes during the face extraction – smile, open-mouth, closed-eyes, glasses, dark-glasses, beard and mustache.

- **Age estimation.** VeriLook can optionally estimate person’s age by analyzing the detected face in the image.

- **Face image quality determination.** A quality threshold can be used during face enrollment to ensure that only the best quality face template will be stored into database.

- **Tolerance to face position.** VeriLook allows for 360 degrees of head roll. Head pitch can be up to 15 degrees in each direction from the frontal position. Head yaw can be up to 45 degrees in each direction from the frontal position. See technical specifications for more details.

- **Multiple samples of the same face.** Biometric template record can contain multiple face samples belonging to the same person. These samples can be enrolled from different sources and at different times, thus allowing improvement in matching quality. For example, a person might be enrolled with and without beard or mustache, etc.

- **Identification capability.** VeriLook functions can be used in 1-to-1 matching (verification), as well as 1-to-many mode (identification). The VeriLook 10.0 face template matching algorithm can compare up to 40,000 faces per second on a PC. See technical specifications for more details.

- **Features generalization mode.** This mode generates the collection of the generalized face features from several images of the same subject. Then, each face image is processed, features are extracted, and the collections of features are analyzed and combined into a single generalized features collection, which is written to the database. This way, the enrolled feature template is more reliable and the face recognition quality increases considerably.

- **Near-infrared and visible light** spectrum face images can be used for face recognition. VeriLook algorithm is able to match faces, which were captured in near-infrared spectrum, against faces, captured in visible light. See the testing results for details.
VeriLook SDK is based on VeriLook face recognition technology and is intended for biometric systems developers and integrators. The SDK allows rapid development of biometric applications using functions from the VeriLook algorithm that ensure fast and reliable face identification. VeriLook can be easily integrated into the customer’s security system. The integrator has complete control over SDK data input and output.

VeriLook SDK includes the Device Manager library that allows to perform simultaneous capture from multiple cameras. Integrators can write plug-ins to support their cameras or other devices using the plug-in framework provided with the Device Manager.

VeriLook is available as the following SDks:
- **VeriLook 10.0 Standard SDK** is designed for PC-based, embedded or mobile biometric application development. It includes Face Matcher, Face Extractor and Face Verification component licenses, programming samples and tutorials, Device Manager library and software documentation. The SDK allows the development of biometric applications for Microsoft Windows, Linux, Mac OS X, iOS or Android operating systems.
- **VeriLook 10.0 Extended SDK** is designed for biometric Web-based and network application development. It includes all features and components of the Standard SDK. Additionally, the SDK contains Face Client component licenses for PCs and mobile / embedded devices, sample client applications, tutorials and a ready-to-use matching server component.

The table below compares VeriLook 10.0 Standard SDK and VeriLook 10.0 Extended SDK. See the licensing model for more information on specific license types.

<table>
<thead>
<tr>
<th>Component licenses that are included with a specific SDK</th>
<th>VeriLook 10.0 Standard SDK</th>
<th>VeriLook 10.0 Extended SDK</th>
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<tbody>
<tr>
<td>• Face Verification component</td>
<td>1 single computer license</td>
<td>1 single computer license</td>
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<tr>
<td>• Face Matcher</td>
<td>1 single computer license</td>
<td>1 single computer license</td>
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<tr>
<td>• Embedded Face Matcher for Android</td>
<td>1 single computer license</td>
<td>1 single computer license</td>
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<tr>
<td>• Embedded Face Matcher for iOS</td>
<td>1 single computer license</td>
<td>1 single computer license</td>
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<tr>
<td>• Embedded Face Matcher for ARM Linux</td>
<td>1 single computer license</td>
<td>1 single computer license</td>
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<tr>
<td>• Face Client (1)</td>
<td>3 single computer licenses</td>
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<tr>
<td>• Embedded Face Client for Android</td>
<td>3 single computer licenses</td>
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<td>• Embedded Face Client for iOS</td>
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<td>• Embedded Face Client for ARM Linux</td>
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<tr>
<td>• Face Extractor</td>
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<td>• Embedded Face Extractor for Android</td>
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<td>• Embedded Face Extractor for iOS</td>
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<td>• Embedded Face Extractor for ARM Linux</td>
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<tr>
<td>• Matching Server</td>
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</table>

(1) Face Client component includes Face Extractor, Face Token Image and Face BSS components, which can be also obtained separately.

VeriLook 10.0 SDK includes programming samples and tutorials that show how to use the components of the SDK to perform face template extraction or matching against other templates. The samples and tutorials are available for these programming languages and platforms:

<table>
<thead>
<tr>
<th>Programming samples and tutorials</th>
<th>Windows 32 &amp; 64 bit</th>
<th>Linux 32 &amp; 64 bit</th>
<th>Mac OS X</th>
<th>Android</th>
<th>iOS</th>
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<tr>
<td>• C/C++</td>
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<td>• Objective-C</td>
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<td>• C#</td>
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<td>• Java</td>
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<tr>
<td>• Visual Basic .NET</td>
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</table>
Biometric Components Description

Face Verification component
The Face Verification component is designed for simple integration of facial recognition technology into high-security applications, like mobile banking transactions, which need only biometric identity verification. The component is intended to provide its functionality for reasonable price, especially for large-scale deployments.

The following operations are available via the high-level API:

- **Face enrollment** into the internal database – an image with a face is captured from a camera, the face template is extracted from the image and saved into the database. Custom metainformation (like person's name) can be provided during calling this operation to store it in the database together with the face template. Up to 10 records can be stored in the database.
- **Face verification** against a specific face from the database – an image with a face is captured from a camera, the face template is extracted from the image and matched against the template stored in the specified database record.
- Database record removal.

Integrators can enable or disable face liveness detection to prevent fraud attempts with a photo. Also, parameters like template size or matching quality threshold can be modified before calling the enrollment or verification operations.

One Face Verification component license is included with VeriLook 10.0 Standard SDK and VeriLook 10.0 Extended SDK for all supported desktop and mobile platforms. More licenses for this component can be purchased any time by VeriLook 10.0 SDK customers.

Face Matcher
The Face Matcher performs facial template matching in 1-to-1 (verification) and 1-to-many (identification) modes. Also the Face Matcher component includes fused matching algorithm that allows to increase template matching reliability by matching templates that contain fingerprint, face, voiceprint and/or iris records (note that matching fingerprint, irises and voiceprints requires to purchase Fingerprint Matcher, Iris Matcher and Voice Matcher components correspondingly - these components are available in VeriFinger 10.0 SDK, VeriEye 10.0 SDK and VeriSpeak 10.0 SDK correspondingly; see these products brochures for more information).

The Face Matcher component matches 40,000 faces per second and is designed to be used in desktop or mobile biometric systems, which run on PCs or laptops with at least Intel Core 2 Q9400 (2.67 GHz) processor.

One Face Matcher license is included with VeriLook 10.0 Standard SDK and VeriLook 10.0 Extended SDK. More licenses for this component can be purchased any time by VeriLook 10.0 SDK customers.

Embedded Face Matcher
The Embedded Face Matcher has the same functionality, as the Face Matcher. It matches 3,000 faces per second and is designed to be used in embedded or mobile biometric systems, which run on ARM Linux, Android or iOS devices. The Android devices should be based on at least Snapdragon S4 system-on-chip (Krait 300 processor with 4 cores running at 1.51 GHz).

One Embedded Face Matcher license for each of Android, iOS and ARM Linux platforms is included with VeriLook 10.0 Standard SDK and VeriLook 10.0 Extended SDK. More licenses for this component can be purchased any time by VeriLook 10.0 SDK customers.
Face Client
The Face Client component is a combination of the Face Extractor, Face Token Image and Face BSS components. It is designed for the systems that need to support all functionality of the mentioned components on the same PC. Using these licenses allows to optimize component license costs as well as reduce license management.

The Face Client extracts a single face template in 0.6 seconds. The specified performance requires a PC or laptop with at least Intel Core 2 Q9400 (2.67 GHz) processor.

Three licenses for the Face Client component are included with VeriLook 10.0 Extended SDK. More licenses for this component can be purchased any time by VeriLook 10.0 Extended SDK customers.

Embedded Face Client
The Embedded Face Client component has the same functionality as the Face Client and is designed to run on Android or iOS or ARM Linux devices. The Android devices should be based on at least Snapdragon S4 system-on-chip (Krait 300 processor with 4 cores running at 1.51 GHz). The component extracts a single face template in 1.34 seconds.

Three licenses for the Embedded Face Client component for each of Android, iOS and ARM Linux platforms are included with VeriLook 10.0 Extended SDK. More licenses for this component can be purchased any time by VeriLook 10.0 Extended SDK customers.

Face Extractor
Face Extractor creates face templates from face images. The Extractor can generalize a face template from several images that include the same face to improve the template’s quality.

Device Manager software allows to perform simultaneous capture from multiple cameras. Integrators can write plug-ins to support their cameras or other devices using the plug-in framework provided with the Device Manager.

The component extracts a single face template in 1.34 seconds. The specified performance requires a PC or laptop with at least Intel Core 2 Q9400 (2.67 GHz) processor.

One Face Extractor license is included with VeriLook 10.0 Standard SDK and VeriLook 10.0 Extended SDK. More licenses for this component can be purchased any time by VeriLook 10.0 SDK customers.

Embedded Face Extractor
The Embedded Face Extractor has the same functionality as the Face Extractor and is designed to be run on Android or iOS or ARM Linux devices. The Android devices should be based on at least Snapdragon S4 system-on-chip (Krait 300 processor with 4 cores running at 1.51 GHz). The component extracts a single face template in 1.34 seconds.

One Embedded Face Extractor license for each of Android, iOS and ARM Linux platforms is included with VeriLook 10.0 Standard SDK and VeriLook 10.0 Extended SDK. More licenses for this component can be purchased any time by VeriLook 10.0 SDK customers.
Face Token Image

The Face Token Image component is designed to provide token face images compatible with the Face Image Format as in ISO/IEC 19794 standard. This face image format enables range of applications on variety of devices, including devices that have limited resources required for data storage, and improves recognition accuracy by specifying data format, scene constraints (lighting, pose), photographic properties (positioning, camera focus) and digital image attributes (image resolution, image size).

The Face Token Image component has the following features:

- Face Token Image creation from an image containing human face using eye coordinates which may be either hand marked or detected automatically using Neurotechnology face detection algorithm.
- Face is detected and eye coordinates are acquired using state-of-the-art Neurotechnology face detection and recognition algorithm.
- Geometrical face image normalization according to the proportions and photographic properties, which are specified in ISO/IEC 19794 standard.
- Intelligent image padding algorithm for cutting off parts of Face Token Image as specified in ISO/IEC 19794 standard.
- Evaluation of the created token face image for the following quality criteria suggested in ISO/IEC 19794 standard:
  - Background uniformity – the background in the token face image should be uniform, not cluttered.
  - Sharpness – the token face image should not be blurred.
  - Too light or too dark images – the token face image should not be too dark or too light.
  - Exposure range of an image – the token face image should have a reasonable exposure range to represent as much details of the subject in the image as possible.
- Evaluation of the token face image quality based on suggestions of ISO/IEC 19794 standard (using the quality criteria above)
- Captured faces can be checked for compliancy with ICAO requirements. These requirements are checked:
  - image pixelation, washed out colors;
  - face darkness, skin tone, skin reflections, glasses reflections;
  - red eyes, looking away eyes (the red eyes can be corrected automatically).

The Face Token Image component also includes proprietary algorithms for this functionality:

- Person’s gender recognition.
- Emotions detection: confidence values returned for neutral mood, anger, disgust, fear, happiness, sadness and surprise.
- Facial feature points extraction for each person from an image.
- Age estimation for each person from an image.
- Additional face attributes detection: smile, open-mouth, blink (closed-eyes), glasses, dark-glasses, beard and mustache.
- Live face detection can be used for determining whether a face in a video stream belongs to a real human or is a photo. See recommendations for live face detection for more information.

The component is designed for desktop or mobile applications that run on PC or laptop with at least Intel Core 2 Q9400 (2.67 GHz) processor. It can be used from C/C++, C# and Java applications on all supported platforms. .NET wrappers of Windows libraries are provided for .NET developers.

Licenses for the Face Token Image component can be purchased anytime by VeriLook 10.0 Extended SDK customers.

Notes:
1. Token in this context is used as "symbolic image, good enough image for machine recognition".
2. Face template should be extracted with the Face Extractor before using these algorithms.
Face BSS (Biometric Standards Support)

The Face BSS (Biometric Standards Support) component allows to integrate support for facial image format standards and additional image formats with new or existing biometric systems based on VeriLook SDK.

These biometric standards are supported:

- **BioAPI 2.0 (ISO/IEC 19784-1:2006)** (Framework and Biometric Service Provider for Face Identification Engine)
- **CBEFF V1.2 (ANSI INCITS 398-2008)** (Common Biometric Exchange Formats Framework)
- **CBEFF V3.0 (ISO/IEC 19785-3:2015)** (Common Biometric Exchange Formats Framework)
- **ISO/IEC 19794-5:2005** (Biometric Data Interchange Formats - Face Image Data)
- **ISO/IEC 19794-5:2011** (Biometric Data Interchange Formats - Face Image Data)
- **ANSI/INCITS 385-2004** (Face Recognition Format for Data Interchange)
- **ANSI/NIST-CSL 1-1993** (Data Format for the Interchange of Fingerprint, Facial, & SMT Information)
- **ANSI/NIST-ITL 1a-1997** (Data Format for the Interchange of Fingerprint, Facial, & SMT Information)
- **ANSI/NIST-ITL 1-2000** (Data Format for the Interchange of Fingerprint, Facial, & SMT Information)
- **ANSI/NIST-ITL 1-2007** (Data Format for the Interchange of Fingerprint, Facial, & Other Biometric Information)
- **ANSI/NIST-ITL 1a-2009** (Data Format for the Interchange of Fingerprint, Facial, & Other Biometric Information)
- **ANSI/NIST-ITL 1a-2011** (Data Format for the Interchange of Fingerprint, Facial, & Other Biometric Information)
- **ANSI/NIST-ITL 1a-2011 Update:2015** (Data Format for the Interchange of Fingerprint, Facial, & Other Biometric Information)

Face BSS component also allows to integrate **JPEG 2000** with Lossy and Lossless Face Profiles support into applications based on VeriLook SDK.

Licenses for the Face BSS component can be purchased anytime by VeriLook 10.0 Extended SDK customers.
Matching Server

The Matching Server is ready-to-use software intended for building moderate size web-based and other network-based systems like local single- or multi-biometric identification system. The Server software runs on a server PC and allows to perform the biometric template matching on server side using Face Matcher component.

Fused multi-biometric matching can be enabled by running components for fingerprint, face and iris matching on the same machine.

Client communication module that allows sending a task to the Matching Server, querying status of the task, getting the results and removing the task from server, is included with MegaMatcher 10.0 SDK, VeriFinger 10.0 SDK, VeriLook 10.0 SDK, VeriSpeak 10.0 SDK and VeriEye 10.0 SDK. This module hides all low level communications and provides high-level API for the developer.

The components and database support modules with source codes included for Matching Server component are listed in the table below. Custom modules for working with other databases can also be developed by integrator and used with the Matching Server software.

The table below shows what components are available with Matching Server software.

<table>
<thead>
<tr>
<th>Components</th>
<th>Microsoft Windows 32 &amp; 64 bit</th>
<th>Linux 32 &amp; 64 bit</th>
<th>Mac OS X</th>
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<tbody>
<tr>
<td>• Matching server software</td>
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<tr>
<td>• Server administration tool API</td>
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<td>Database support modules</td>
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<td>• Microsoft SQL Server</td>
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<td>• C# client</td>
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<td>• Visual Basic .NET client</td>
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<td>• C#</td>
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<tr>
<td>• Visual Basic .NET</td>
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</table>

The Matching Server component requires a special license that allows to run the component on all machines that run the fingerprint, face, iris or palm print matching components obtained by an integrator. The Matching Server software is included with VeriLook 10.0 Extended SDK.

Also the Matching Server component is included with these Neurotechnology SDKs (see their brochures for more info):

- MegaMatcher 10.0 Standard or MegaMatcher 10.0 Extended SDK;
- VeriFinger 10.0 Extended SDK;
- VeriEye 10.0 Extended SDK.
- VeriSpeak 10.0 Extended SDK.
Basic Recommendations for Facial Recognition

Face recognition accuracy of VeriLook heavily depends on the quality of a face image. **Image quality during enrollment is important**, as it influences the quality of the face template.

**General recommendations**

- **32 pixels is the recommended minimal distance between eyes** for a face on image or video stream to perform face template extraction reliably. **64 pixels or more** recommended for better face recognition results. Note that this distance should be native, not achieved by resizing an image.

- **Several images during enrollment** are recommended for better facial template quality which results in improvement of recognition quality and reliability.

- **Additional enrollments** may be needed when **facial hair** style changes, especially when beard or mustache is grown or shaved off.

**Face posture**

The face recognition engine has certain tolerance to face posture:

- **head roll** (tilt) – ±180 degrees (configurable).
  - **±15 degrees default** value is the fastest setting which is usually sufficient for most near-frontal face images.

- **head pitch** (nod) – ±15 degrees from frontal position.
  - The head pitch tolerance can be increased up to ±25 degrees if several views of the same face that covered different pitch angles were used during enrollment.

- **head yaw** (bobble) – ±90 degrees from frontal position (configurable).
  - **±15 degrees default** value is the fastest setting which is usually sufficient for most near-frontal face images.
  - **30 degrees difference** between a face template in a database and a face image from camera is **acceptable**.
  - Several views of the same face can be enrolled to the database to cover the whole ±90 degrees yaw range from frontal position.

*Continued on the next page*
Live Face Detection

A stream of consecutive images (usually a video stream from a camera) is required for face liveness check:

- When the liveness check is enabled, it is performed by the face engine before feature extraction. If the face in the stream **fails** to qualify as “live”, the features are **not extracted**.
- Only **one face should be visible** in these frames.
- Users can enable these liveness check modes:
  - **Active** – the engine requests the user to perform certain actions like blinking or moving one’s head.
    - 5 frames per second or better frame rate required.
    - This mode can work with both colored and grayscale images.
    - This mode requires the user to perform all requested actions to pass the liveness check.
  - **Passive** – the engine analyzes certain facial features while the user stays still in front of the camera for a short period of time.
    - Colored images are required for this mode.
    - 10 frames per second or better frame rate required.
    - Better score is achieved when users do not move at all.
  - **Passive then active** – the engine first tries the passive liveness check, and if it fails, tries the active check. This mode requires colored images.
  - **Simple** – the engine requires user to turn head from side to side while looking at camera.
    - 5 frames per second or better frame rate recommended.
    - This mode can work with both colored and grayscale images.
Supported Cameras

These cameras are supported by VeriLook SDK:

- Any webcam or camera that is accessible using:
  - DirectShow interface for Microsoft Windows platform
  - GStreamer interface for Linux platforms.
  - QuickTime interface for Mac platform.

- Any built-in smartphone or tablet camera that is supported by iOS or Android OS. The camera should have at least 0.3 MegaPixel (640 x 480 pixels) resolution.

- These advanced cameras are supported:
  - IrisGuard IG-AD100 – face & iris camera (Microsoft Windows only)
  - VistaFA2 / VistaFA2E / VistaEY2 face & iris cameras (Microsoft Windows only)

- These models of still cameras are supported:
  - Canon EOS family still cameras (Microsoft Windows only)
  - Nikon DSLR still cameras (Microsoft Windows only; a specific camera model should support video capture)

- Cameras, which can operate in near-infrared spectrum, can be used for image capture. VeriLook algorithm is able to match faces, captured in near-infrared spectrum, against faces, captured in visible light. See the testing results for details.

- A video file can be also used as a data source for applications based on VeriLook SDK.

- Integrators can also write plug-ins to support their cameras using the plug-in framework provided with the Device Manager from the VeriLook SDK.

Simultaneous capture from multiple cameras is possible.

High resolution cameras may be used with VeriLook, but more powerful technology like MegaMatcher SDK or SentiVeillance SDK is recommended for acceptable performance. These cameras are supported:

- Any IP camera, that supports RTSP (Real Time Streaming Protocol):
  - Only RTP over UDP is supported.
  - VLC framework can be optionally used for reading video streams.
  - H.264/MPEG-4 AVC or Motion JPEG should be used for encoding the video stream.

- Also these specific models of high-resolution cameras are supported:
  - Axis M1114 camera (Microsoft Windows and Linux)
  - Basler BIP2-1600-25c-DN IP camera (Microsoft Windows and Linux)
  - Cisco 4500 IP camera (Microsoft Windows only)
  - PiXORD N606 camera (Microsoft Windows and Linux)
  - Prosilica GigE Vision camera (Microsoft Windows and Linux)
  - Sony SNC-CS50 camera (Microsoft Windows and Linux)
  - Uniview IPC2322EBR-DPZ28 camera
System requirements

There are specific requirements for each platform which will run VeriLook-based applications.

Microsoft Windows platform requirements

- Microsoft Windows Vista / 7 / 8 / 10, 32-bit or 64-bit.
  - Windows XP is no longer supported in this version of the SDK. If your product requires to support Windows XP, you may consider the previous version of the SDK. Please contact us for more information.
- PC or laptop with x86 (32-bit) or x86-64 (64-bit) compatible processors.
  - 2 GHz or better processor is recommended.
  - SSE2 support is required. Processors that do not support SSE2 cannot run the VeriLook algorithm. Please check if a particular processor model supports SSE2 instruction set.
- At least 128 MB of free RAM should be available for the application. Additional RAM is required for applications that perform 1-to-many identification, as all biometric templates need to be stored in RAM for matching. For example, 10,000 templates (each with 1 face record) require about 50 MB of additional RAM.
- Free space on hard disk drive (HDD):
  - at least 1 GB required for the development.
  - 100 MB required for VeriLook components deployment.
  - Additional space would be required in these cases:
    - VeriLook does not require the original face image to be stored for the matching; only the templates need to be stored. However, storing face images on hard drive for the potential future usage is recommended.
    - Usually a database engine runs on a separate computer (back-end server). However, DB engine can be installed on the same computer for standalone applications. In this case HDD space for templates storage must be available. For example, 10,000 templates (each with 1 face record) stored using a relational database would require about 50 MB of free HDD space.
- A camera or webcam. See the previous chapter for more details.
- Database engine or connection with it. VeriLook templates can be saved into any DB (including files) supporting binary data saving. VeriLook Extended SDK contains the following support modules for Matching Server on Microsoft Windows platform: Microsoft SQL Server, MySQL, Oracle, PostgreSQL and SQLite.
- Network/LAN connection (TCP/IP) for client/server applications. Also, network connection is required for using Matching server component (included in VeriLook Extended SDK). Communication with Matching server is not encrypted, therefore, if communication must be secured, a dedicated network (not accessible outside the system) or a secured network (such as VPN; VPN must be configured using operating system or third party tools) is recommended.
- Microsoft .NET framework 4.5 or newer (for .NET components usage).
- One of following development environments for application development:
  - Microsoft Visual Studio 2012 or newer (for application development under C/C++, C#, Visual Basic .Net)
  - Sun Java 1.6 SDK or later.
Android platform requirements

- A smartphone or tablet that is running **Android 4.4 (API level 19)** OS or newer.
  - If you have a custom Android-based device or development board, contact us to find out if it is supported.
- **ARM-based 1.5 GHz processor recommended** for face processing in the specified time. Slower processors may be also used, but the face processing will take longer time.
- At least **20 MB of free RAM** should be available for the application. Additional RAM is required for applications that perform 1-to-many identification, as all biometric templates need to be stored in RAM for matching. For example, **1,000 templates** (each with 1 face record) require about **5 MB of additional RAM**.
- **Free storage** space (built-in flash or external memory card):
  - 30 MB required for embedded face components deployment for each separate application.
  - Additional space would be required if an application needs to store original face images. VeriLook does not require the original face image to be stored for the matching; only the templates need to be stored.
- Any smartphone’s or tablet’s **built-in camera** which is supported by Android OS. The camera should have at least 0.3 MegaPixel (640 x 480 pixels) resolution.
- **Network/LAN connection (TCP/IP)** for client/server applications. Also, network connection is required for using Matching server component (included in VeriLook Extended SDK). Communication with Matching server is not encrypted, therefore, if communication must be secured, a dedicated network (not accessible outside the system) or a secured network (such as VPN; VPN must be configured using operating system or third party tools) is recommended.
- **PC-side development** environment requirements:
  - Java SE JDK 6 (or higher)
  - Eclipse Indigo (3.7) IDE
  - Android development environment (at least API level 19 required)
  - One of the following build automation systems:
    - Apache Maven 3.1.x or newer
    - Gradle 4.4 or newer
  - Internet connection for activating VeriLook component licenses
iOS platform requirements

- One of the following devices, running iOS 8.0 or newer:
  - iPhone 5 or newer iPhone.
  - iPad 2 or newer iPad, including iPad Mini and iPad Air models.
  - iPod Touch 6th Generation or newer iPod.
- At least 20 MB of free RAM should be available for the application. Additional RAM is required for applications that perform 1-to-many identification, as all biometric templates need to be stored in RAM for matching. For example, 1,000 templates (each with 1 face record) require about 5 MB of additional RAM.
- Free storage space (built-in flash or external memory card):
  - 30 MB required for embedded face components deployment for each separate application.
  - Additional space would be required if an application needs to store original face images. VeriLook does not require the original face image to be stored for the matching; only the templates need to be stored.
- Network/LAN connection (TCP/IP) for client/server applications. Also, network connection is required for using Matching server component (included in VeriLook Extended SDK). Communication with Matching server is not encrypted, therefore, if communication must be secured, a dedicated network (not accessible outside the system) or a secured network (such as VPN; VPN must be configured using operating system or third party tools) is recommended.
- Development environment requirements:
  - a Mac running Mac OS X 10.10.x or newer.
  - Xcode 6.4 or newer.
Mac OS X platform requirements

- A Mac running Mac OS X 10.7.x or newer. 2 GHz or better processor is recommended.

- At least **128 MB of free RAM** should be available for the application. Additional RAM is required for applications that perform 1-to-many identification, as all biometric templates need to be stored in RAM for matching. For example, **10,000 templates** (each with 1 face record) require about **50 MB of additional RAM**.

- **Free space on hard disk drive (HDD):**
  - at least 1 GB required for the development.
  - 100 MB required for VeriLook components deployment.
  - Additional space would be required in these cases:
    - VeriLook does not require the original face image to be stored for the matching; only the templates need to be stored. However, storing face images on hard drive for the potential future usage is recommended.
    - Usually a database engine runs on a separate computer (back-end server). However, DB engine can be installed on the same computer for standalone applications. In this case HDD space for templates storage must be available. For example, 10,000 templates (each with 1 face record) stored using a relational database would require about 50 MB of free HDD space. Also, the database engine itself requires HDD space for running. Please refer to HDD space requirements from the database engine providers.

- A **camera** or **webcam**. See the previous chapter for more details.

- **Database engine** or connection with it. VeriLook templates can be saved into any DB (including files) supporting binary data saving. VeriLook Extended SDK contains SQLite support modules for Matching Server on Mac OS X platform.

- **Network/LAN connection (TCP/IP)** for client/server applications. Also, network connection is required for using Matching server component (included in VeriLook Extended SDK). Communication with Matching server is not encrypted, therefore, if communication must be secured, a dedicated network (not accessible outside the system) or a secured network (such as VPN; VPN must be configured using operating system or third party tools) is recommended.

- Specific requirements for **application development**:
  - XCode 4.3 or newer
  - wxWidgets 3.0.0 or newer libs and dev packages (to build and run SDK samples and applications based on them)
  - GNU Make 3.81 or newer (to build samples and tutorials development)
  - Sun Java 1.6 SDK or later.
Linux x86 / x86-64 platform requirements

- Linux 2.6 or newer kernel (32-bit or 64-bit) is required. **Linux 3.0 kernel** or newer is recommended.
- PC or laptop with **x86 (32-bit)** or **x86-64 (64-bit)** compatible processors.
  - 2 GHz or better processor is recommended.
  - **SSE2 support is required.** Processors that do not support SSE2 cannot run the VeriLook algorithm. Please check if a particular processor model supports SSE2 instruction set.
- At least **128 MB of free RAM** should be available for the application. Additional RAM is required for applications that perform 1-to-many identification, as all biometric templates need to be stored in RAM for matching. For example, **10,000 templates** (each with 1 face record) require about **50 MB of additional RAM**.

Free space on hard disk drive (HDD):
- at least 1 GB required for the development.
- 100 MB required for VeriLook components deployment.
- Additional space would be required in these cases:
  - VeriLook does not require the original face image to be stored for the matching; only the templates need to be stored. However, storing face images on hard drive for the potential future usage is recommended.
  - Usually a database engine runs on a separate computer (back-end server). However, DB engine can be installed on the same computer for standalone applications. In this case HDD space for templates storage must be available. For example, 10,000 templates (each with 1 face record) stored using a relational database would require about 50 MB of free HDD space. Also, the database engine itself requires HDD space for running. Please refer to HDD space requirements from the database engine providers.

- A **camera** or **webcam**. See the previous chapter for more details.
- glibc 2.13 library or newer
- GStreamer 1.2.2 or newer with gst-plugin-base and gst-plugin-good is required for face capture using camera/webcam or rtsp video. GStreamer 1.4.x or newer is recommended.
- **Database engine** or connection with it. VeriLook templates can be saved into any DB (including files) supporting binary data saving. VeriLook Extended SDK contains **MySQL, Oracle, PostgreSQL** and **SQLite** support modules for Matching Server on Linux x86 / x86-64 platforms.
- **Network/LAN connection (TCP/IP)** for client/server applications. Also, network connection is required for using Matching server component (included in VeriLook Extended SDK). Communication with Matching server is not encrypted, therefore, if communication must be secured, a dedicated network (not accessible outside the system) or a secured network (such as VPN; VPN must be configured using operating system or third party tools) is recommended.

Specific requirements for application development:
- wxWidgets 3.0.0 or newer libs and dev packages (to build and run SDK samples and applications based on them)
- GCC-4.4.x or newer
- GNU Make 3.81 or newer (to build samples and tutorials development)
- Sun Java 1.6 SDK or later.
- pkg-config-0.21 or newer (optional; only for Matching Server database support modules compilation)
**ARM Linux platform requirements**

We recommend to contact us and report the specifications of a target device to find out if it will be suitable for running VeriLook-based applications. There is a list of common requirements for ARM Linux platform:

- A device with ARM-based processor, running **Linux 3.2 kernel** or newer.
- ARM-based **1.5 GHz processor recommended** for face processing in the specified time.
  - **ARMHF architecture (EABI 32-bit hard-float ARMv7)** is required.
  - Lower clock-rate processors may be also used, but the face processing will take longer time.
- At least **20 MB of free RAM** should be available for the application. Additional RAM is required for applications that perform 1-to-many identification, as all biometric templates need to be stored in RAM for matching. For example, **1,000 templates** (each with 1 face record) require about **5 MB of additional RAM**.
- **Free storage** space (built-in flash or external memory card):
  - 100 MB required for VeriLook components deployment.
  - Additional space would be required if an application needs to store original face images. VeriLook does not require the original face image to be stored for the matching; only the templates need to be stored.
- A **camera** or **webcam**. See the previous chapter for more details.
- glibc 2.13 library or newer
- libstdc++-v3 4.7.2 or newer.
- **Network/LAN connection (TCP/IP)** for client/server applications. Also, network connection is required for using Matching server component (included in VeriLook Extended SDK). Communication with Matching server is not encrypted, therefore, if communication must be secured, a dedicated network (not accessible outside the system) or a secured network (such as VPN; VPN must be configured using operating system or third party tools) is recommended.
- **Development environment** requirements:
  - GCC-4.4.x or newer
  - GNU Make 3.81 or newer
  - JDK 1.6 or later
Technical Specifications

32 pixels is the minimal distance between eyes for a face on image or video stream to perform face template extraction reliably. 64 pixels or more recommended for better template extraction results.

All face templates should be loaded into RAM before identification, thus the maximum face template database size is limited by the amount of available RAM.

VeriLook has certain tolerance to face posture that assures face enrollment convenience:

- head roll (tilt) – ±180 degrees (configurable);
  ±15 degrees default value is the fastest setting which is usually sufficient for most near-frontal face images.
- head pitch (nod) – ±15 degrees from frontal position.
- head yaw (bobble) – ±90 degrees from frontal position (configurable);
  ±15 degrees default value is the fastest setting which is usually sufficient for most near-frontal face images.

Also, see above the list of recommendations and constraints for facial recognition.

VeriLook 10.0 face detection algorithm can run in maximal speed or maximal accuracy modes. The face detection times in the table below are provided for 640 x 480 pixels images as ranges, where the smallest time corresponds to the maximal speed mode, and the largest time – to the maximal accuracy. The head pitch tolerance in the table below is always ±15°.

<table>
<thead>
<tr>
<th>Roll tolerance</th>
<th>Yaw tolerance</th>
<th>Intel Core i7-4771</th>
</tr>
</thead>
<tbody>
<tr>
<td>±15°</td>
<td>±15°</td>
<td>6 - 11</td>
</tr>
<tr>
<td>±15°</td>
<td>±45°</td>
<td>10 - 23</td>
</tr>
<tr>
<td>±45°</td>
<td>±45°</td>
<td>23 - 53</td>
</tr>
<tr>
<td>±180°</td>
<td>±15°</td>
<td>53 - 132</td>
</tr>
<tr>
<td>±180°</td>
<td>±45°</td>
<td>130 - 330</td>
</tr>
</tbody>
</table>

VeriLook biometric template extraction and matching algorithm is designed to run on multi-core processors allowing to reach maximum possible performance on the used hardware. Face template extraction is performed after all faces are detected in a frame. The template extraction time does not depend on image size.

VeriLook 10.0 face engine specifications

<table>
<thead>
<tr>
<th>Android-based platform (1)</th>
<th>PC-based platform (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Template extraction components</td>
<td>Template extraction time (seconds)</td>
</tr>
<tr>
<td>Embedded Face Extractor</td>
<td>1.34</td>
</tr>
<tr>
<td>Embedded Face Client</td>
<td>1.20</td>
</tr>
<tr>
<td>Template matching components</td>
<td>Template matching speed (faces per second)</td>
</tr>
<tr>
<td>3,000</td>
<td>40,000</td>
</tr>
<tr>
<td>Single face record size in a template (bytes)</td>
<td>4,028 or 5,066 or 7,128 (configurable)</td>
</tr>
</tbody>
</table>

(1) Requires to be run on Android devices based on at least Snapdragon S4 system-on-chip with Krait 300 processor (4 cores, 1.51 GHz).
(2) Requires to be run on PC or laptop with at least Intel Core 2 Q9400 quad-core processor (2.67 GHz) to reach the specified performance.
Reliability Tests

We present the testing results to show the VeriLook 10.0 algorithm template matching reliability evaluations. The following public datasets were used:

- **NIST Special Database 32 - Multiple Encounter Dataset (MEDS-II).** - [http://www.nist.gov/itl/iad/ig/sd32.cfm](http://www.nist.gov/itl/iad/ig/sd32.cfm)
  - All full-profile face images from the dataset were removed because they are not supported by VeriLook SDK. This resulted in 1,216 images of 518 persons.

  - According to the original protocol, only 6,000 pairs (3,000 genuine and 3,000 impostor) should be used to report the results. But recent algorithms are "very close to the maximum achievable by a perfect classifier" [http://people.cs.umass.edu/~elm/papers/LFW_survey.pdf](http://people.cs.umass.edu/~elm/papers/LFW_survey.pdf). Instead, as Neurotechnology algorithms were not trained on any image from this dataset, verification results on matching each pair of all 13,233 face images of 5,729 persons were chosen to be reported.
  - All identity mistakes, which had been mentioned on the LFW website, were fixed. Also, several not mentioned issues were fixed.
  - Some images from the LFW dataset contained multiple faces. The correct faces for assigned identities were chosen manually to solve these ambiguities.

- **CASIA NIR-VIS 2.0 Database.** - [http://www.cbsr.ia.ac.cn/english/NIR-VIS-2.0-Database.html](http://www.cbsr.ia.ac.cn/english/NIR-VIS-2.0-Database.html)
  - The dataset contains face images, which were captured in visible light (VIS) and near-infrared (NIR) spectrums. According to the original protocol, VeriLook algorithm testing used VIS images as gallery, and NIR images as probe.
  - According to the original protocol, the dataset is split into two parts – View1 intended for algorithm development and View2 for performance evaluation. Neurotechnology algorithms were not trained on any image from this dataset. Only View2 part with 12,393 NIR images and 2,564 VIS images was used for face verification evaluation.
  - The non-cropped images (640 x 480 pixels) from the dataset were used for VeriLook algorithm testing.

The MEDS-II and LFW datasets contained faces, which are impossible to detect with the fastest near-frontal face detection. Face detection parameters were tuned to fully automatically detect maximum amount of faces with highest recall ratio using ±45° detectors, no speed optimizations, smaller search step and other parameters.

Two experiments were performed with each dataset:

- **Experiment 1** maximized matching accuracy. VeriLook 10.0 algorithm reliability in this test is shown on the ROC charts as blue curves.
- **Experiment 2** maximized matching speed. VeriLook 10.0 algorithm reliability in this test is shown on the ROC charts as red curves.

Receiver operation characteristic (ROC) curves are usually used to demonstrate the recognition quality of an algorithm. ROC curves show the dependence of false rejection rate (FRR) on the false acceptance rate (FAR). Equal error rate (EER) is the rate at which both FAR and FRR are equal. The ROC charts and the testing results are available on the next pages.
VeriLook 10.0 SDK matching engine with face templates from NIST Multiple Encounter Dataset (MEDS-II):
- Experiment 1, maximized matching accuracy scenario
- Experiment 2, maximized matching speed scenario

VeriLook 10.0 SDK matching engine with face templates from the University of Massachusetts Labeled Faces in the Wild (LFW) dataset:
- Experiment 1, maximized matching accuracy scenario
- Experiment 2, maximized matching speed scenario
VeriLook 10.0 algorithm testing results with face images from public datasets

<table>
<thead>
<tr>
<th></th>
<th>MEDS-II</th>
<th>LFW</th>
<th>NIR-VIS 2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exp. 1</td>
<td>Exp. 2</td>
<td>Exp. 1</td>
</tr>
<tr>
<td>Image count</td>
<td>1216</td>
<td>13233</td>
<td>14957</td>
</tr>
<tr>
<td>Subject count</td>
<td>518</td>
<td>5729</td>
<td>725</td>
</tr>
<tr>
<td>Session count</td>
<td>1 - 18</td>
<td>1 - 530</td>
<td>4</td>
</tr>
<tr>
<td>Image size (pixels)</td>
<td>variable</td>
<td>250 x 250</td>
<td>480 x 640</td>
</tr>
<tr>
<td>Template size (bytes)</td>
<td>7128</td>
<td>5066</td>
<td>7128</td>
</tr>
<tr>
<td>EER</td>
<td>0.9247 %</td>
<td>1.0550 %</td>
<td>0.6135 %</td>
</tr>
<tr>
<td>FRR at 0.1 % FAR</td>
<td>2.1770 %</td>
<td>3.8100 %</td>
<td>2.2920 %</td>
</tr>
<tr>
<td>FRR at 0.01 % FAR</td>
<td>5.9860 %</td>
<td>10.1100 %</td>
<td>7.5900 %</td>
</tr>
<tr>
<td>FRR at 0.001 % FAR</td>
<td>15.1900 %</td>
<td>16.2400 %</td>
<td>17.9700 %</td>
</tr>
</tbody>
</table>

VeriLook 10.0 SDK matching engine with face templates from the CASIA NIR-VIS 2.0 dataset (captured in visible light and near-infrared spectrum):
- Experiment 1, maximized matching accuracy scenario
- Experiment 2, maximized matching speed scenario
VeriLook Demo, Trial SDK and Related Products

VeriLook algorithm demo application and VeriLook 30-day SDK Trial are available for downloading at www.neurotechnology.com/download.html.

These products are related to VeriLook SDK (see the corresponding product brochure for more information):

- **Face Verification SDK** – for developing of lightweight high-security applications, designed for large-scale deployment; the Face Verification SDK is included with the VeriLook SDK.

- **SentiVeillance Server** – ready-to-use software for easy integration of biometric face identification and person tracking into video management systems (VMS).

- **SentiVeillance SDK** – allows to create software for performing biometric face identification and pedestrian or vehicle or other object motion tracking using live video streams from high-resolution digital surveillance cameras. SentiVeillance component is capable of performing automatic multiple face tracking, enrollment and matching against database.

- **SentiMask SDK** – 3D face tracking for augmented reality apps and digital characters control.

- **MegaMatcher SDK** – for development of AFIS or multi-biometric face, fingerprint, iris, voiceprint and palm print identification products.

- **MegaMatcher On Card SDK** – a product for fingerprint, iris and face matching on smart cards.

- **NCheck Bio Attendance** – an end-user employee attendance management application designed as ready-to-use time and attendance system with biometric face, fingerprint and iris identification; VeriLook facial recognition algorithm is used in the application for checking person identity.

- **NVeiler Video Filter** – a plug-in for VirtualDub video processing application that is able to detect and hide faces in videos; VeriLook algorithm is used for the face detection feature of the plug-in.
Licensing VeriLook SDK

Product Development
An integrator should obtain either a VeriLook 10.0 Standard SDK (EUR 339) or VeriLook 10.0 Extended SDK (EUR 859) to develop an end-user product based on VeriLook technology. The SDK needs to be purchased just once and may be used for all projects and by all the developers within the integrator’s company.

See the “Contents of VeriLook Standard SDK and Extended SDK” chapter (page 4) for the list of component licenses included with VeriLook 10.0 Standard and VeriLook 10.0 Extended SDK.

Integrators can obtain additional component licenses if more component licenses are required for the development process.

Product Deployment
To deploy their developed products, an integrator need obtain licenses of components for every computer or device, where component will be installed together with integrator’s product. See Product Advisor to find out what specific components will be needed for the deployment of your system. Integrators can purchase additional VeriLook component licenses if required at anytime.

License activation options
The components are copy-protected. The following license activation options are available:

- **Serial numbers** are used to activate licenses for particular VeriLook components on particular computer or device. The activation is done via the Internet or by email. After activation the network connection is not required for single computer license usage.
  
  **Notes:**
  1. Activation by serial number is not suitable for iOS and ARM-Linux platforms, except BeagleBone Black and Raspberry Pi 3 devices.
  2. Activation by serial number is not suitable for virtual environments.

- **Internet activation.** A special license file is stored on a computer or a mobile or embedded device; the license file allows to run particular VeriLook components on that computer or device after checking the license over the Internet. Internet connection should be available periodically for a short amount of time. A single computer license can be transferred to another computer or device by moving the license file there and waiting until the previous activation expires.

- **Volume License Manager.** Licenses may be stored in a volume license manager dongle. License activation using volume license manager may be performed without connection to the Internet and is suitable for virtual environments. Volume license manager is used on site by integrators or end users to manage licenses for VeriLook components in the following ways:
  1. Activating single computer licenses – An installation license for a VeriLook component will be activated for use on a particular computer. The number of available licenses in the license manager will be decreased by the number of activated licenses.
  2. Managing single computer licenses via a LAN or the Internet – The license manager allows the management of installation licenses for VeriLook components across multiple computers or mobile/embedded devices in a LAN or over the Internet. The number of managed licenses is limited by the number of licenses in the license manager. No license activation is required and the license quantity is not decreased. Once issued, the license is assigned to a specific computer or device on the network.
  3. Using license manager as a dongle – A volume license manager containing at least one license for a VeriLook component may be used as a dongle, allowing the VeriLook component to run on the particular computer where the dongle is attached.
Licenses Validity
All SDK and component licenses are perpetual and do not have expiration. There are no annual fee or any other fees except license purchasing fee. It is possible to move licenses from one computer or device to another. Neurotechnology provides a way to renew the license if the computer undergoes changes due to technical maintenance.

Licensing Agreement
The Licensing Agreement (http://neurotechnology.com/mm_100_sla.html) contains all licensing terms and conditions.
Note that you unambiguously accept this agreement by placing an order using Neurotechnology online ordering service or by email or other means of communications. Please read the agreement before making an order.

Other licensing options
- **VAR License.** The above described licensing model is intended for end-user product developers. Integrators who want to develop and sell a VeriLook-based development tool (with API, programming possibilities, programming samples, etc.), must obtain permission from Neurotechnology and sign a special VAR agreement. For more information please contact us.

- **Enterprise License.** The VeriLook enterprise license allows an unlimited use of VeriLook components in end-user products for a specific territory, market segment or project. Specific restrictions would be included in the licensing agreement. The enterprise license price depends on the application size and the number of potential users of the application within the designated territory, market segment or project. For more information please contact us.
Prices for VeriLook products

- The prices are effective June 21, 2017. The prices may change in the future, so please download and review the latest version of the brochure before making an order.
- Quantity discounts do not accumulate over time, prices do not include local import duties or taxes.
- Customers with Solution Partner status are eligible for product discounts.

<table>
<thead>
<tr>
<th>VeriLook SDK</th>
<th></th>
</tr>
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<tbody>
<tr>
<td>VeriLook 10.0 Standard SDK</td>
<td>€ 339.00</td>
</tr>
<tr>
<td>VeriLook 10.0 Extended SDK</td>
<td>€ 859.00</td>
</tr>
</tbody>
</table>

Face Verification component for all platforms (prices per single computer license)

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 9</td>
<td>€ 1.75</td>
</tr>
<tr>
<td>10 - 19</td>
<td>€ 1.27</td>
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<td>20 - 49</td>
<td>€ 1.13</td>
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<tr>
<td>50 - 99</td>
<td>€ 1.00</td>
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<tr>
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<td>€ 0.89</td>
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<tr>
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<tr>
<td>500 - 999</td>
<td>€ 0.69</td>
</tr>
<tr>
<td>1000 - 1999</td>
<td>€ 0.62</td>
</tr>
<tr>
<td>2000 and more</td>
<td>Please contact us for more information</td>
</tr>
</tbody>
</table>

Face components for PCs (prices per single computer license)

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Face Extractor</th>
<th>Face Client (1)</th>
<th>Face Token Image (1)</th>
<th>Face BSS (1)</th>
<th>Face Matcher</th>
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<tbody>
<tr>
<td>1 - 9</td>
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Embedded face components (prices per single computer license)

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License management

| Volume license manager | € 16.00 |

(1) These components are not available for VeriLook Standard SDK customers.

VeriLook products can be ordered:
- online, at www.neurotechnology.com/cgi-bin/order.cgi
- via a local Neurotechnology distributor; the list of distributors is available at www.neurotechnology.com/distributors.html