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Embedded and
mobile face
identification

VeriLook Embedded SDK



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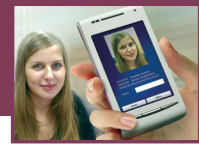
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VeriLook Embedded facial identification technology is intended for mobile biometric systems developers and integrators. The technology assures simultaneous multiple face recognition and face matching in 1-to-1 and 1-to-many modes with PC-like reliability.

VeriLook Embedded is available as a software development kit that allows development of stand-alone or Web-based solutions for smartphones, tablets and other devices that are running **Android OS**.

- More than a million algorithm deployments worldwide.
- PC-level recognition quality on mobile and embedded devices.
- Compatibility and interoperability with VeriLook- and MegaMatcher-based products.
- Live face detection prevents cheating with a photo in front of a camera.
- Simultaneous multiple face processing in live video and still images.
- Reasonable prices, flexible licensing and free customer support.



VeriLook Embedded algorithm features and capabilities

VeriLook Embedded face recognition algorithm is intended for embedded and mobile biometric system integrators. The VeriLook Embedded 1.1 technology is a port of VeriLook 5.2 technology for ARM-based processors.

VeriLook Embedded provides the same quality of PC-based facial recognition on embedded and mobile devices. The technology implements advanced face localization, enrollment and matching using robust digital image processing algorithms:

- **Simultaneous multiple face processing.** VeriLook Embedded performs accurate detection of multiple faces in **live video** streams and still images.
- **Live face detection.** A conventional face identification system can be easily cheated by placing a photo of another person in front of a camera. VeriLook Embedded is able to prevent this kind of security breach by determining whether a face in a video stream belongs to a real human or is a photo.
- **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 posture.** VeriLook Embedded allows 360 degrees 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 with different face postures and expressions, from different sources and in different time thus allowing to improve matching quality. For example a person could be enrolled with and without eyeglasses or with different eyeglasses, with and without beard or moustache, with different face expressions like smiling and non-smiling etc.
- **Identification capability.** VeriLook Embedded functions can be used in 1-to-1 matching (verification), as well as 1-to-many mode (identification).
- **Small face features template.** A face features template can be only **4 Kilobytes**, thus VeriLook Embedded based applications can handle **large face databases**. Larger templates can be used to increase matching reliability. 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.



Contents of VeriLook Embedded SDK

VeriLook Embedded SDK is based on VeriLook Embedded face recognition technology and is intended for biometric systems developers and integrators. The SDK allows rapid development of biometric applications for smart phones, tablets and other devices that are running Android OS. The integrator has complete control over SDK data input/output and can call the functions from the VeriLook Embedded algorithm that ensure fast and reliable face identification.

VeriLook Embedded SDK is able to capture images and video streams from cameras that are built-in in Android devices.

The VeriLook Embedded 1.1 SDK contains:

- **Embedded Face Extractor** – 1 single computer license;
- **Embedded Face Matcher** – 1 single computer license;
- **Java** language programming samples and tutorials;
- VeriLook Embedded SDK documentation.

See the “licensing model” chapter below for more information on specific license types.

Embedded Face Extractor component

Embedded Face Extractor creates face templates from face images. Image quality control can be applied to accept only good quality face images.

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

See “technical specifications” chapter below for the template extraction speed, the size of face template and the requirements for image size and camera resolution.

One Embedded Face Extractor license is included with VeriLook Embedded 1.1 SDK. More licenses for this component can be purchased any time by VeriLook Embedded 1.1 SDK customers.

Embedded Face Matcher component

The Embedded Face Matcher performs facial template matching in 1-to-1 (verification) and 1-to-many (identification) modes.

“Reliability tests” chapter below contain information about the template matching quality in different scenarios.

One Embedded Face Matcher license is included with VeriLook Embedded 1.1 SDK. More licenses for this component can be purchased any time by VeriLook Embedded 1.1 SDK customers.



Basic Recommendations for Facial Recognition

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

There are some basic recommendations and constraints when using face recognition applications based on VeriLook Embedded SDK.

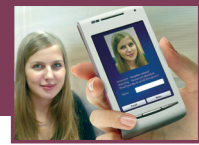
Cameras and images

- **Similar quality cameras** are recommended for both enrollment and identification. Using the same camera model is even better.
- **50 pixels is the recommended minimal distance between eyes** for a face on image or video stream to perform face template extraction. **75 pixels or more** recommended for better face recognition results. Note that this distance should be **native**, not achieved by resizing an image.
- **640 x 480 pixels minimal camera resolution** is recommended for face enrollment and recognition:
 - Make sure that **native** 640 x 480 resolution is provided by a webcam or a smartphone camera, as some of these cameras may have lower resolution that is later **scaled up** to 640 x 480 without image quality improvement. While it is acceptable for video calls or occasional photos, it will introduce additional distortions and artifacts to the face image.
 - Lower resolution webcams are not recommended as optical distortions will appear and affect facial template quality because users will have to be too close to the cameras for successful face detection and enrollment.
- **Check for mirrored face images**, as recognition will fail if a face was enrolled from a mirrored image, and later a non-mirrored face image is used for recognition (or vice versa). This happens as some cameras or devices can be configured to produce mirrored images or may even produce them by default, and different cameras or configurations may be used during enrollment and identification. We recommend to use face images with uniform orientation – all images within a system should be either native or mirrored, but not mixed between each other.
- **Use several images during enrollment**, as it improves facial template quality which results in improvement of recognition quality and reliability.

Lighting

Controlled lighting conditions are recommended:

- **Direct frontal or diffused light** allows equal lighting distribution on each side of the face and from top to bottom with no significant shadows within the face region.
- **Avoid glares** on face skin or glasses that are produced by some types of illumination.



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) – ± 45 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 ± 45 degrees yaw range from frontal position.

Facial expression

Neutral face expression during enrollment is recommended, as non-neutral face expression may affect the accuracy of recognition. Examples of non-neutral face expressions (they are allowed but not recommended):

- Broad smile (when teeth or the inside of the mouth exposed).
- Raised eyebrows.
- Closed eyes.
- Eyes looking away from the camera.
- Frown.

Slight changes in facial expression are acceptable during identification, as they do not influence the accuracy of face recognition.

Glasses, Makeup, Hair, Beard and Moustache

Several images with different appearance variants are recommended for assuring the quality of recognition in the situations when part of face is covered with glasses or hair:

- **Eyeglasses** – separate enrollments with and without glasses will assure the best recognition quality for both cases. Special recommendations:
 - **Sunglasses and regular glasses with heavy frames** will decrease recognition quality, as they cover part of face and some facial features become not visible. If possible, they should be avoided during both enrollment and identification.
 - **Contact lens** – the contact lens do not affect the recognition quality. However, persons wearing them **sometimes may wear eyeglasses** instead of lens. In this case an additional enrollment with eyeglasses is recommended.
- **Heavy makeup** is not recommended as it can hide or distort facial features.
- **Hair style** – some hair styles may cover parts of face, thus **hairpins** or other means of holding hair off the face are recommended during enrollment.
- **Facial hair** style changes may require additional enrollments, especially when beard or moustache is grown or shaved off.



System requirements

- A **smartphone** or **tablet** or other device that is running **Android 2.2 (API 8)** OS or newer.
- ARM-based **1 GHz processor recommended** for face processing in less than 1 second. 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 containing 1 face record) require about **5 MB of additional RAM**.
- **Free storage space** (built-in flash or external memory card):
 - 30 MB required for VeriLook Embedded components deployment for each separate application.
 - Additional space would be required if an application needs to store original face images. VeriLook Embedded does not require the original face image to be stored for the matching; only the templates need to be stored.
- **Camera (optional)**. VeriLook Embedded is able to work with all cameras that are supported by Android OS. At least **0.3 MegaPixel (640 x 480 pixels)** camera is required for the VeriLook Embedded biometric algorithm. Integrators may also use image files or receive image data from external devices like flatbed scanners or stand-alone cameras.
- **Network connection**. A VeriLook Embedded-based application may require network connection for **activating** the VeriLook Embedded component licenses. See the list of available activation options in the “licensing model” chapter below for more information. Also, network connection may be required for **client/server** applications.
- **PC-side development environment requirements:**
 - Java SE JDK 6 (or higher)
 - Eclipse Indigo (3.7) IDE
 - Android development environment (at least API 8 required)
 - Maven 3.0.x
 - Internet connection for activating VeriLook Embedded component licenses



Technical Specifications

640 x 480 pixels is the recommended minimal image size for faces' detection. Face template extraction and matching is not dependent on the image size.

50 pixels is the **minimal distance between eyes** for a face on image or video stream to perform face template extraction. **75 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 Embedded 1.1 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) – ± 45 degrees from frontal position (configurable);
 ± 15 degrees default value is the fastest setting which is usually sufficient for most near-frontal face images.

See above also the whole list of recommendations and constraints for facial recognition.

A Java application based on VeriLook Embedded 1.1 technology is able to process a face image in **less than 1 second**.

Facial record size in a template can be chosen from three values: **4 kilobytes**, 20 kilobytes and 36 kilobytes. Several facial records can be stored in the template.



Reliability tests

We present the testing results to show practical VeriLook Embedded 1.1 algorithm reliability evaluations. Face images from **FRGC** database were used for testing, thus the testing results can be compared with testing results of other algorithms.

Experiment 1 and *Experiment 2* were performed according to FRGC protocol:

- **Experiment 1** measures performance on the recognition from frontal facial images taken under controlled illumination. The biometric samples in the target and query sets consist of a **single controlled still image** in high resolution.
- **Experiment 2** is designed to examine the effect of multiple still images on performance. The biometric samples in the target and query sets are composed of the **4 controlled images** of each person from a subject.

See *Overview of the Face Recognition Grand Challenge* (http://face.nist.gov/frgc/FRGC_CVPR05_Overview.pdf) for more details on FRGC experiments protocol.

Each experiment was performed 2 times to test different scenarios:

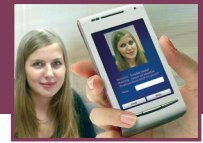
- **Test 1** maximized **matching accuracy**. VeriLook Embedded 1.1 algorithm reliability in this test is shown on the ROC charts as **red** curves for Experiment 1 and **cyan** curves for Experiment 2.
- **Test 2** minimized **template size**. VeriLook Embedded 1.1 algorithm reliability in this test is shown on the ROC charts as **green** curves for Experiment 1 and **magenta** curves for Experiment 2.

These sets of ROC curves were calculated using certain subsets of FRGC database for each experiment and test according to FRGC protocol:

- **ROC I** – gallery and probe photos were taken within half of the year.
- **ROC II** – gallery and probe photos were taken within one year.
- **ROC III** – gallery and probe photos were taken with time lapse of at least half of the year but within 1.5 year.

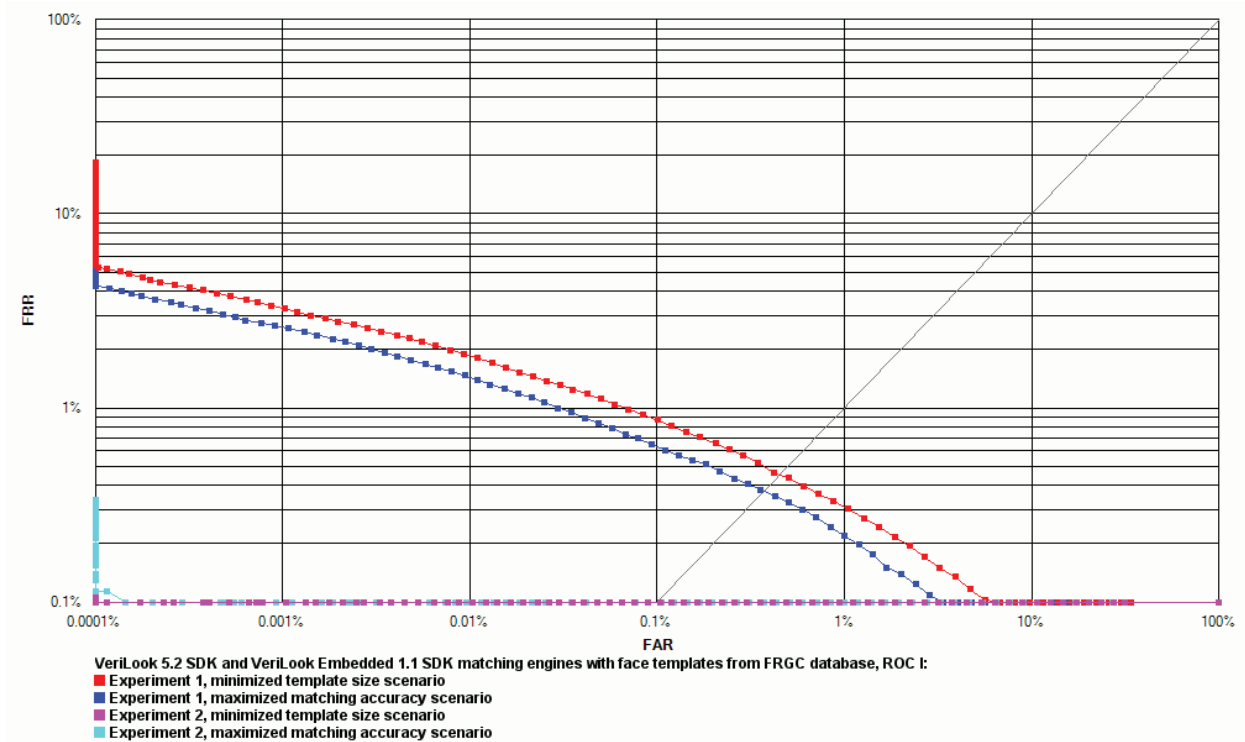
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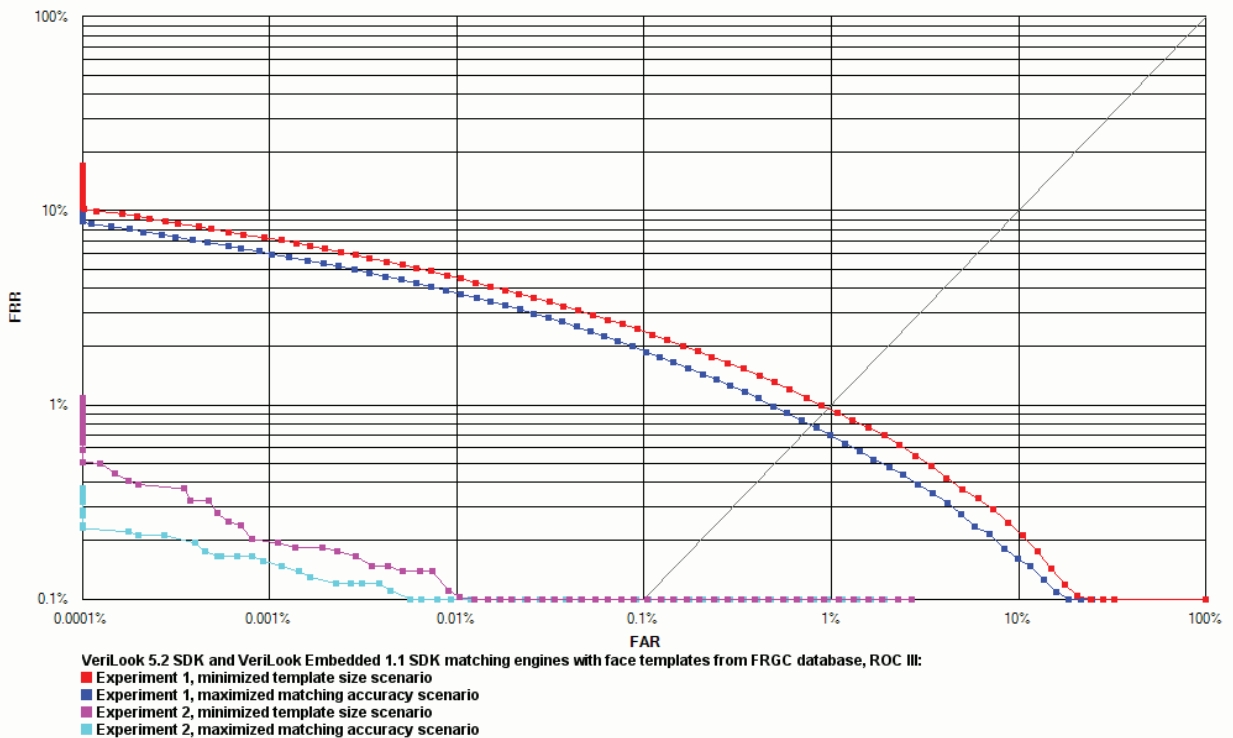
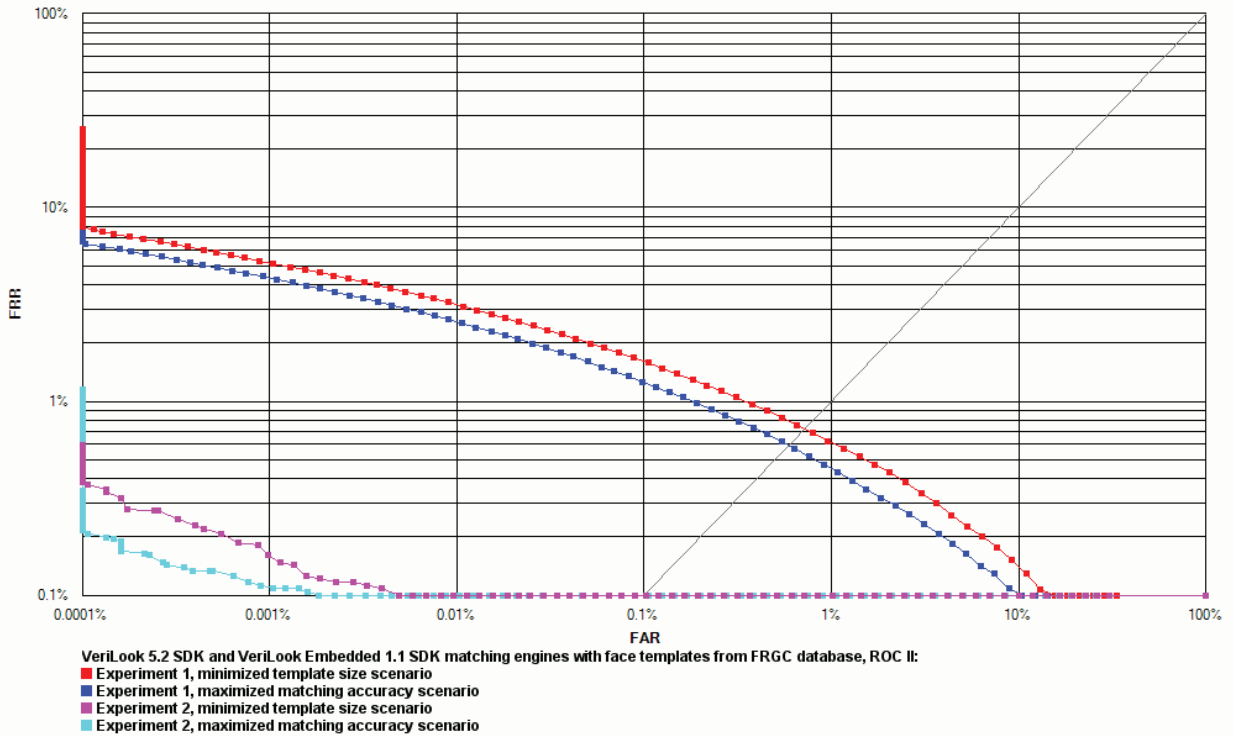
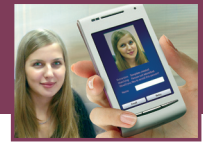
- VeriLook Embedded 1.1 face template matching engine is a **port** of VeriLook 5.2 PC-based engine for ARM-based processors, thus the reliability testing results and the ROC curves for both engines **are the same**.
- Part of images in the FRGC database is 1600 x 1200 pixels, and the other part is 2272 x 1704 pixels, as the images for this database were obtained with digital photo camera. The technical specifications above are given for 640 x 480 pixels images that are common for webcams.
- Head roll, pitch and yaw were set to $\pm 15^\circ$ during all experiments and tests.
- No score normalization techniques were applied while calculating these ROC curves, although FRGC protocol allowed to use score normalization.

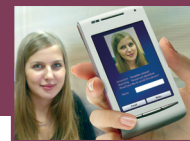


VeriLook Embedded 1.1 algorithm reliability tests with FRGC database (FRR at 0.1 % FAR)

	Experiment 1		Experiment 2	
	Test 1	Test 2	Test 1	Test 2
ROC I	0.6497 %	0.9227 %	0.0569 %	0.0569 %
ROC II	1.2620 %	1.6780 %	0.0476 %	0.0476 %
ROC III	2.0060 %	2.4590 %	0.0370 %	0.0370 %







VeriLook Embedded SDK Trial and Related Products

VeriLook Embedded **30-day SDK Trial** is available for downloading at www.neurotechnology.com/download.html.

These products are related to VeriLook Embedded SDK:

- **VeriLook SDK** – intended for development of PC-based or Web-based facial identification systems. VeriLook SDK optionally includes ready-to-use PC-side matching server software that can be used together with mobile clients based on VeriLook Embedded SDK. See “VeriLook SDK” brochure for more information.
- **MegaMatcher SDK** – intended for development of AFIS or multi-biometric face, fingerprint, iris, voice and palm print identification products. MegaMatcher SDK includes ready-to-use PC-side matching server software that can be used together with mobile clients based on VeriLook Embedded SDK. See “MegaMatcher SDK” brochure for more information.
- **VeriLook Surveillance SDK** – intended for development of systems that perform biometric face identification using live video streams from high-resolution digital surveillance cameras. VeriLook Surveillance accepts face templates created by mobile applications based on VeriLook Embedded SDK. See “VeriLook Surveillance SDK” brochure for more information.



Licensing VeriLook Embedded SDK

The following licensing model is intended for **end-user** product developers. Integrators who want to develop and sell a VeriLook Embedded 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.

Product Development

An integrator should obtain a VeriLook Embedded 1.1 SDK (EUR 339) to develop a product based on VeriLook Embedded technology. The SDK needs to be purchased just once and may be used by all the developers within the integrator's company.

VeriLook Embedded SDK includes a number of components; each particular component has specific functionality. A **license** for an individual VeriLook Embedded component is required for **each CPU** that **runs** the component (a processor can have any number of cores).

These components are included with VeriLook Embedded 1.1 SDK:

- 1 single computer license for Embedded Face Matcher
- 1 single computer license for Embedded Face Extractor

Components are copy-protected – a license is required for a component to run. License activation options are listed below.

Additional component licenses may be obtained by VeriLook Embedded SDK customers as required by their development process.

Product Deployment

To deploy a product developed with VeriLook Embedded 1.0/1.1 SDK, an integrator need to obtain only the additional licenses required for the particular VeriLook Embedded 1.1 components that will run on **each CPU** of their customer's computers. The available VeriLook Embedded components and license types for product deployment are the same as for product development.

Each VeriLook Embedded component running on a device or computer belonging to the integrator's customer requires a license. License activation options are listed below on this page.

Prices for VeriLook Embedded 1.1 SDK and additional VeriLook Embedded component licenses can be found in the next section.



Single computer licenses

A single computer license allows the installation and running of a VeriLook Embedded component installation on one CPU (a processor can have any number of cores).

Each single computer license requires **activation** for a VeriLook Embedded component to run. The available activation options are listed below.

Additional single computer licenses for VeriLook Embedded components may be obtained at any time by VeriLook Embedded SDK customers.

License activation options

Single computer and concurrent network licenses are supplied in two ways:

- **Internet activation.** A special **license file** is stored on a device or computer; the license file allows to run particular VeriLook Embedded components on that device or computer after **checking** the license over the Internet. **Internet connection** should be available for a short period of time at least **once in 7 days**. A single computer license can be **transferred** to another device or computer by moving the license file there and waiting until the previous activation expires.
- Licenses may be stored in a volume license manager **dongle**. License activation using volume license manager may be performed without connection to the Internet.

Volume license manager

Volume license manager is **used on site** by integrators or end users to **manage** single computer licenses for VeriLook Embedded components **via a LAN or the Internet**. It consists of license management software and a dongle, used to store the purchased licenses.

The license manager allows the management of installation licenses for VeriLook Embedded components across multiple devices or computers in the network. The number of managed licenses is limited by the number of licenses in the license manager. Once issued, the license is assigned to a specific device or computer on the network.

The volume license manager **requires a PC** with Microsoft Windows, Linux or Mac OS X to run the license management software; the dongle would be connected to the PC.

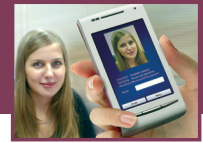
Additional VeriLook component licenses for the license manager may be purchased at any time. Neurotechnology will generate an update code and send it to you. Simply enter the code into the license manager to add the purchased licenses.

VeriLook Embedded enterprise license

The VeriLook Embedded enterprise license allows an **unlimited use** of VeriLook Embedded 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. VeriLook Embedded enterprise licenses are intended for larger projects, with pricing starting at **EUR 20,000**.

For more information please contact us.



Prices for VeriLook Embedded products

- The prices are **effective from April 2, 2012**. 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.
- The prices do not include any local import duties or taxes.
- Product shipping cost depends on delivery country
- Our customers can gain a discount for our products by getting the Solution Partner status.

VeriLook Embedded SDK

VeriLook Embedded 1.1 SDK license	€ 339.00
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Embedded face components (prices per single computer license)

Quantity	Embedded Face Extractor	Embedded Face Matcher
1-9	€ 13.00	€ 17.00
10-19	€ 10.00	€ 12.00
20-49	€ 8.70	€ 10.80
50-99	€ 7.50	€ 9.60
100-199	€ 6.70	€ 8.40
200-499	€ 6.00	€ 7.60
500-999	€ 5.30	€ 6.80
1000-1999	€ 4.70	€ 6.00
2000-3999	€ 4.20	€ 5.40
4000-7999	€ 3.80	€ 4.80
8000 and more	Please contact us for more information	

License management

Volume license manager	€ 16.00
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VeriLook Embedded enterprise license

VeriLook Embedded 1.1 enterprise license	Please contact us for more information
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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