



NEUROtechnology



Face
identification
for PC or Web
applications

VeriLook SDK



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Face identification for PC or Web applications

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VeriLook facial identification technology is intended 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 PC- and Web-based solutions on Microsoft Windows, Linux and Mac OS X platforms.

- More than a million algorithm deployments worldwide.
- Live face detection prevents cheating with a photo in front of a camera.
- Simultaneous multiple face processing in live video and still images.
- Webcams or other low cost cameras are suitable for obtaining face images.
- Available as multiplatform SDK that supports multiple programming languages.
- Surveillance SDK is available for integrating face identification into surveillance systems.
- 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).

Neurotechnology has developed a **PC-based face recognition algorithm VeriLook 5.2** designed for biometric system integrators. The VeriLook algorithm implements advanced face localization, enrollment and matching using robust digital image processing algorithms:

- **Simultaneous multiple face processing.** VeriLook 5.2 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 each face is processed in **0.03 - 0.17 seconds** depending on defined template size. Optionally, the facial feature points (both eyes, nose tip and lips middle point) can be also extracted in 0.1 seconds. See technical specifications for more details.
- **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 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 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 functions can be used in 1-to-1 matching (verification), as well as 1-to-many mode (identification).
- **Fast face matching.** The VeriLook 5.2 face template matching algorithm can compare up to **420,000 faces per second**. See technical specifications for more details.
- **Small face features template.** A face features template can be only **4 Kilobytes**, thus VeriLook-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 5.2 Standard SDK and Extended SDK

VeriLook SDK is based on VeriLook PC-based 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 5.2 Standard SDK** is intended for PC-based biometric application development. It includes Face Matcher and Extractor component licenses, programming samples and tutorials, Device Manager library and software documentation. The SDK allows the development of biometric applications for Microsoft Windows, Linux or Mac OS X operating systems.
- **VeriLook 5.2 Extended SDK** is intended 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, sample client applications, tutorials and a **ready-to-use matching server** component.

The table below compares VeriLook 5.2 Standard SDK and VeriLook 5.2 Extended SDK. See the licensing model for more information on specific license types.

Component licenses that are included with a specific SDK		
	VeriLook 5.2 Standard SDK	VeriLook 5.2 Extended SDK
• Face Matcher	1 single computer license	1 single computer license
• Face Client ⁽¹⁾		3 single computer licenses and 1 concurrent license
• Face Extractor	1 single computer license	1 single computer license
• Matching Server		+

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

VeriLook 5.2 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:

	Microsoft Windows 32 & 64 bit	Linux 32 & 64 bit	Mac OS X
Programming samples			
• C/C++	+	+	+
• C#	+		
• Sun Java 2	+	+	+
• Visual Basic .NET	+		
• Delphi	+		
Programming tutorials			
• C	+	+	+
• C#	+		
• Visual Basic .NET	+		
• Sun Java 2	+	+	+
• Delphi	+		



Biometric Components Description

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 6.5 SDK*, *VeriEye 2.5 SDK* and *VeriSpeak 1.1 SDK* correspondingly; see these products brochures for more information).

“Technical specifications” and “reliability and performance tests” sections contain information about the template matching speeds and recognition quality in different scenarios.

One Face Matcher license is included with VeriLook 5.2 Standard SDK and VeriLook 5.2 Extended SDK. More licenses for this component can be purchased any time by VeriLook 5.2 SDK customers.

Face Client

The Face Client component is a combination of the Face Extractor and Face BSS components. It is intended 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.

Three non-concurrent licenses and one concurrent license for the Face Client component are included with VeriLook 5.2 Extended SDK. More non-concurrent and concurrent licenses for this component can be purchased any time by VeriLook 5.2 Extended SDK customers

Face Extractor

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

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

Live face detection can be used for determining whether a face in a video stream belongs to a real human or is a photo.

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.

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

One Face Extractor license is included with VeriLook 5.2 Standard SDK and VeriLook 5.2 Extended SDK. More licenses for this component can be purchased any time by VeriLook 5.2 SDK customers.



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)
- **ISO/IEC 19794-5:2005** (Face Image Data)
- **ANSI/INCITS 385-2004** (Face Recognition Format for Data Interchange)

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

Neurotechnology Token Face Image (NTFI) module is included in the component.

The NTFI module is intended 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 NTFI module has the following features:

- Token face 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 normalization of face image according to proportions and photographic properties in ISO/IEC 19794 standard.
- Intelligent image padding algorithm for cut of parts of token face image as in ISO/IEC 19794 standard.
- Test the created token face image for 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.
- Evaluate token face image quality based on suggestions of ISO/IEC 19794 standard (Using the quality criteria above).

The Face BSS component 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 BSS component can be purchased anytime by VeriLook 5.2 Extended SDK customers.

**Token in this context is used as “symbolic image, good enough image for machine recognition”. Token Image as in ISO/IEC19794-5: “A Face Image Type that specifies frontal images with a specific geometric size and eye positioning based on the width and height of the image. This image type is suitable for minimizing the storage requirements for computer face recognition tasks such as verification while still offering vendor independence and human verification (versus human examination which requires more detail) capabilities.”*



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 4.3 SDK, VeriFinger 6.5 SDK, VeriLook 5.2 SDK, VeriSpeak 1.1 SDK and VeriEye 2.5 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.

Components	Microsoft Windows 32 & 64 bit	Linux 32 & 64 bit	Mac OS X
• Matching server software	+	+	+
• Server administration tool API	+	+	
Database support modules			
• Microsoft SQL Server	+		
• PostgreSQL	+	+	
• MySQL	+	+	
• Oracle	+	+	
• SQLite	+	+	+
Programming samples			
• C# client	+		
• Visual Basic .NET client	+		
• Sun Java 2 web client	+	+	+
Programming tutorials			
• C/C++	+	+	
• C#	+		
• Visual Basic .NET	+		

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 5.2 Extended SDK.

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

- MegaMatcher 4.3 Standard or MegaMatcher 4.3 Extended SDK;
- VeriFinger 6.5 Extended SDK;
- VeriEye 2.5 Extended SDK.
- VeriSpeak 1.1 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.

There are some basic recommendations and constraints when using face recognition applications based on VeriLook 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, as some webcams have 320 x 240 pixels 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

- **PC or Mac with x86 (32-bit) or x86-64 (64-bit) compatible processors.** 2GHz 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 containing 1 face record) require about **24 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 containing 1 face record) stored using a relational database would require about 30 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.
- **Camera or webcam.** These cameras are supported by VeriLook:
 - Any **webcam** or camera that is accessible using:
 - **DirectShow** interface for Microsoft Windows platform
 - **GStreamer** interface for Linux platform.
 - **QuickTime** interface for Mac platform.
 - Also these specific models of high-resolution cameras are supported:
 - Axis M1114 camera (Microsoft Windows and Linux)
 - Cisco 4500 IP camera (Microsoft Windows only)
 - IrisGuard IG-AD100 face and iris camera (Microsoft Windows only)
 - Mobotix DualNight M12 IP camera (Microsoft Windows and Linux)
 - PiXORD N606 camera (Microsoft Windows and Linux)
 - Prosilica GigE Vision camera (Microsoft Windows only)
 - Sony SNC-CS50 camera (Microsoft Windows and Linux)
 - VistaFA2 / VistaFA2E / VistaEY2 face & iris cameras (Microsoft Windows only)
 - VistaMT Multimodal Biometric Device (Microsoft Windows only)
 - Integrators can also write a **plug-in to support their cameras** using the plug-in framework provided with the Device Manager from the VeriLook SDK.



- **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:
 - Microsoft SQL Server (only for Microsoft Windows platform);
 - PostgreSQL (for Microsoft Windows and Linux platform);
 - MySQL (for Microsoft Windows and Linux platforms);
 - Oracle (for Microsoft Windows and Linux platforms);
 - SQLite (for all 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.

- **Microsoft Windows specific requirements:**
 - Microsoft Windows XP / Vista / 7 / Server 2003 / Server 2008, 32-bit or 64-bit.
 - Microsoft .NET framework 2.0 or newer (for .NET components usage).
 - Microsoft DirectX 9.0 or later (for camera/webcam usage).
 - One of following development environments for application development:
 - Microsoft Visual Studio 2005 SP1 or newer (for development under C/C++, C#, Visual Basic .Net);
 - Sun Java 1.5 SDK or later;
 - Delphi 7.

- **Linux specific requirements:**
 - Linux 2.6 or newer kernel, 32-bit or 64-bit.
 - glibc 2.7 or newer.
 - GStreamer 0.10.23 (with gst-plugin-base and gst-plugin-good) or newer (for face capture using camera/webcam).
 - udev-143 or newer with libudev (for camera usage)
 - GTK+ 2.10.x or newer libs and dev packages (to run SDK samples and applications based on them).
 - GCC-4.0.x or newer (for application development).
 - GNU Make 3.81 or newer (for application development).
 - Sun Java 1.5 SDK or later (for application development with Java).
 - pkg-config-0.21 or newer (optional; only for Matching Server database support modules compilation).

- **Mac OS X specific requirements:**
 - Mac OS X (version 10.4 or newer).
 - QuickTime (for camera/webcam usage).
 - XCode 2.4 or newer (for application development).



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.

All specifications are provided for these processors:

- Intel **Core 2 Q9400** (4 cores), running at **2.67 GHz** clock rate;
- Intel **Core i7-2600** (4 cores), running at **3.4 GHz** clock rate.

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) – ± 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.

VeriLook 5.2 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 $\pm 15^\circ$.

VeriLook 5.2 face detection algorithm performance for all faces in a frame (seconds)			
Roll tolerance	Yaw tolerance	Intel Core 2 Q9400	Intel Core i7-2600
$\pm 15^\circ$	$\pm 15^\circ$	0.015 - 0.025	0.010 - 0.015
$\pm 15^\circ$	$\pm 45^\circ$	0.030 - 0.060	0.020 - 0.035
$\pm 45^\circ$	$\pm 45^\circ$	0.120 - 0.220	0.070 - 0.130
$\pm 180^\circ$	$\pm 15^\circ$	0.200 - 0.360	0.120 - 0.215
$\pm 180^\circ$	$\pm 45^\circ$	0.450 - 0.860	0.270 - 0.510



VeriLook face template matching algorithm can use more than one processor core on **multi-core processors** allowing to increase template matching speed. The template matching speeds in the table below are given as a range, where the smaller number means matching speed using **1 processor core**, while the larger number means matching speed using all **4 processor cores**.

VeriLook 5.2 template extraction and matching algorithm performance				
		Maximized template size	Medium template size	Minimized template size
Single face template extraction time ⁽¹⁾ (seconds)	Intel Core 2 Q9400	0.175	0.095	0.050
	Intel Core i7-2600	0.095	0.050	0.030
Facial feature points extraction time ⁽²⁾ (seconds)	Intel Core 2 Q9400	0.115		
	Intel Core i7-2600	0.065		
Matching speed ⁽³⁾ (faces per second)	Intel Core 2 Q9400	13,000 - 52,000	23,000 - 92,000	105,000 - 420,000
	Intel Core i7-2600	30,000 - 120,000	54,000 - 216,000	240,000 - 960,000
Template size in database ⁽⁴⁾ (bytes)		35,994	20,010	4,026

(1) Face template extraction is performed after all faces are detected in a frame. The template extraction time does not depend on image size, but only on defined template size.

(2) **Optional.** The facial feature points extraction is disabled by default.

(3) The probe template is defined to contain 1 “**large**” face record(s). The gallery templates can contain 1 “small”, “medium” or “large” face record.

(4) When 1 face record stored in a template. Template size increases proportionally when multiple face records are stored in the same template.



Reliability and Performance Tests

We present the testing results to show how VeriLook 5.2 technical specifications correspond the practical algorithm's performance and 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 5.2 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 5.2 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.

Notes:

- 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.



Template matching was performed using **all 4 cores** of the specified processors. The performance tests were performed on PCs with these processors:

- Intel **Core 2 Q9400**, running at **2.67 GHz** clock rate;
- Intel **Core i7-2600**, running at **3.4 GHz** clock rate.

VeriLook 5.2 algorithm testing results with FRGC database on Intel Core 2 Q9400 processor

	Experiment 1		Experiment 2	
	Test 1	Test 2	Test 1	Test 2
Average template extraction speed during enrollment (seconds)	0.218	0.091	0.872	0.364
Template size during enrollment (bytes)	35994	4026	16104 ⁽¹⁾	4026 ⁽²⁾
Average template extraction speed during identification ⁽³⁾ (seconds)	0.218	0.218	0.872	0.872
Template size during identification ⁽³⁾ (bytes)	35994	35994	143976	143976
Template matching speed ⁽³⁾ (templates per second)	53152	425832	30304	114292
FRR at 0.1 % FAR	ROC I	0.6497 %	0.9227 %	0.0569 %
	ROC II	1.2620 %	1.6780 %	0.0476 %
	ROC III	2.0060 %	2.4590 %	0.0370 %

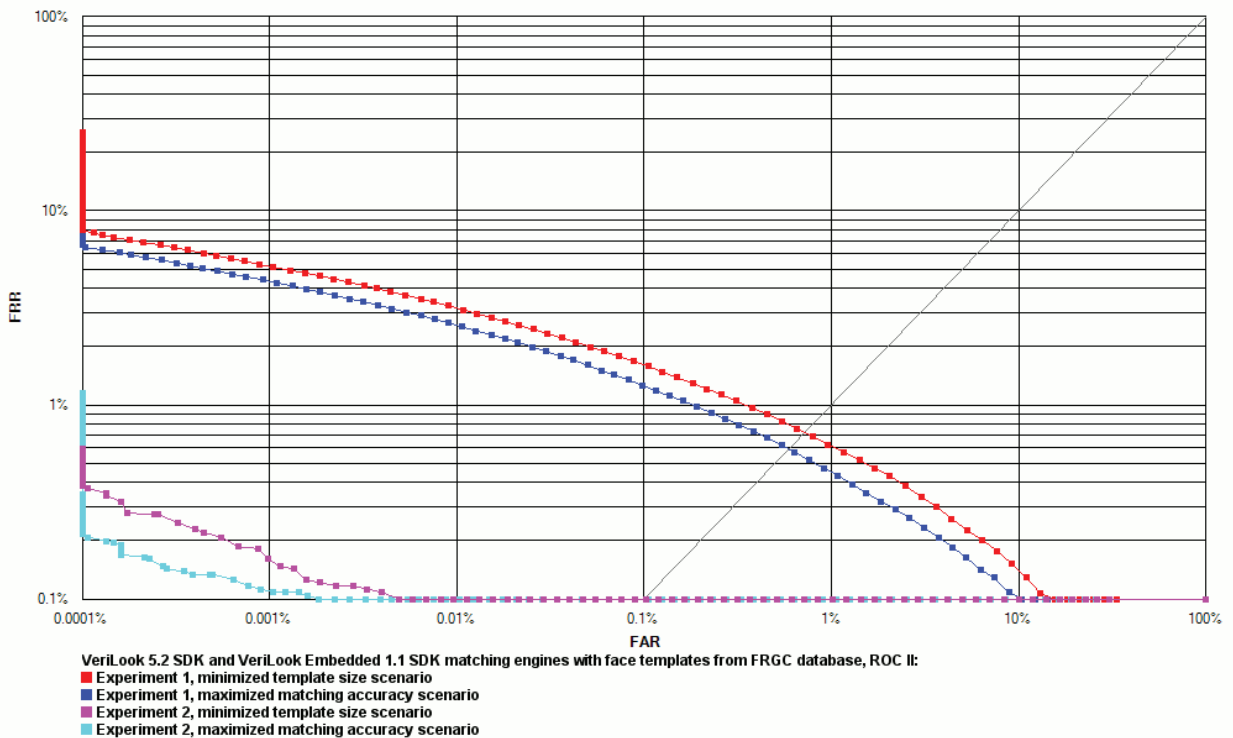
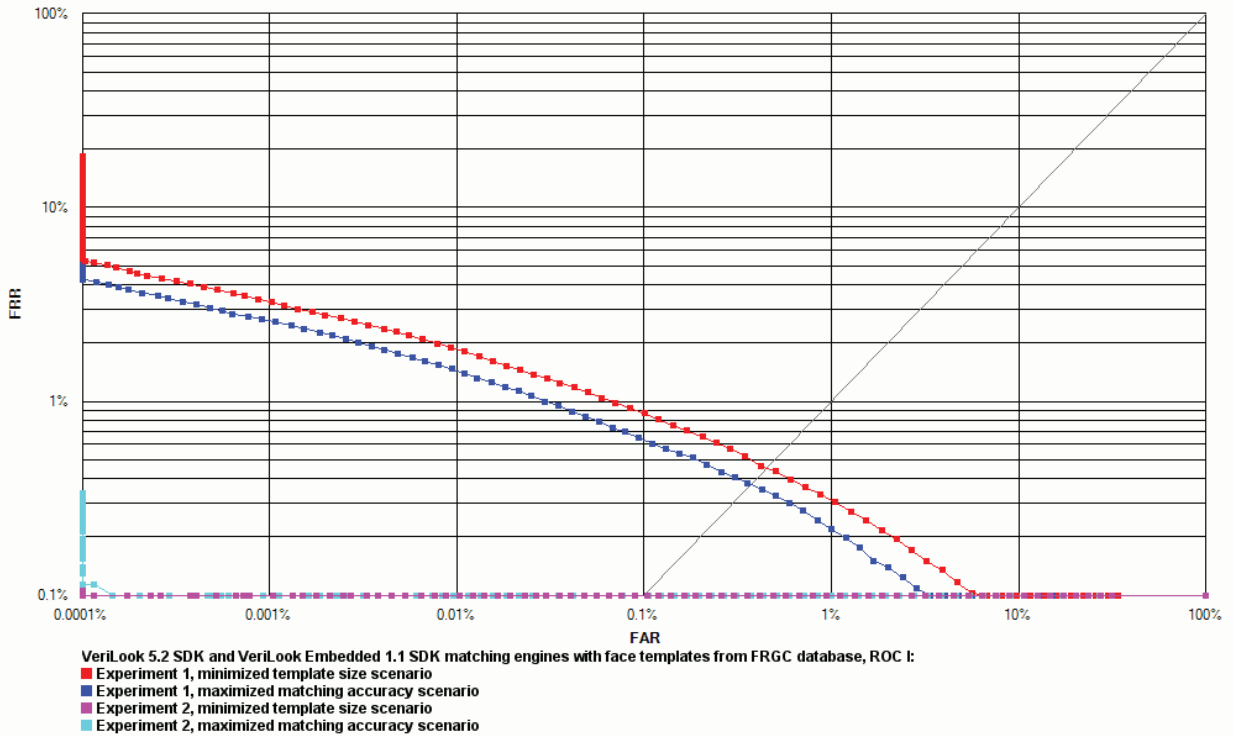
VeriLook 5.2 algorithm testing results with FRGC database on Intel Core i7-2600 processor

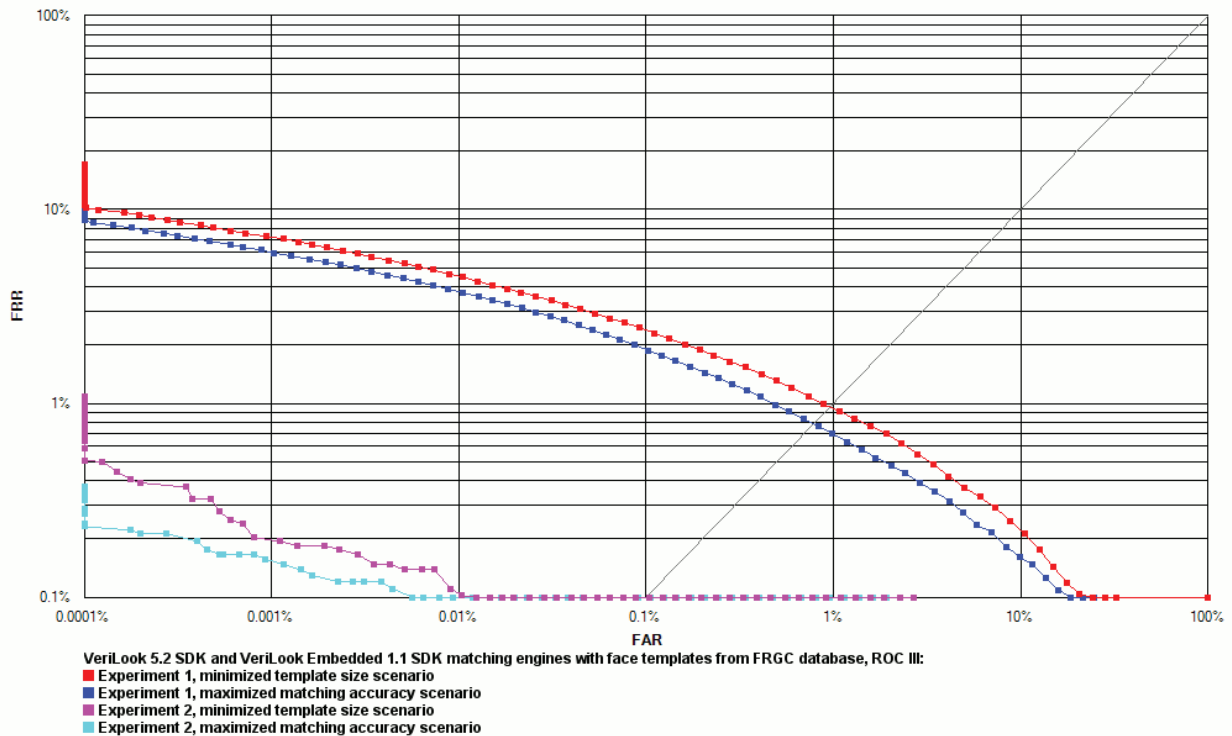
	Experiment 1		Experiment 2	
	Test 1	Test 2	Test 1	Test 2
Average template extraction speed during enrollment (seconds)	0.120	0.053	0.480	0.212
Template size during enrollment (bytes)	35994	4026	16104 ⁽¹⁾	4026 ⁽²⁾
Average template extraction speed during identification ⁽³⁾ (seconds)	0.120	0.120	0.480	0.480
Template size during identification ⁽³⁾ (bytes)	35994	35994	143976	143976
Template matching speed ⁽³⁾ (templates per second)	124744	961704	67296	255056
FRR at 0.1 % FAR	ROC I	0.6497 %	0.9227 %	0.0569 %
	ROC II	1.2620 %	1.6780 %	0.0476 %
	ROC III	2.0060 %	2.4590 %	0.0370 %

(1) Each gallery template contains **4 “small”** face records.

(2) Each gallery template contains **1 “small”** face record that was created by **generalizing** 4 different face records.

(3) The probe template is defined to contain **“large”** face record(s). The gallery templates can contain “small”, “medium” or “large” face record(s).





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:

- **VeriLook Embedded SDK** – a product for facial recognition on Android smartphones, tablets and other mobile devices. Produces face **templates** that are the **same** as in VeriLook SDK, thus can be also used for developing biometric client-side mobile applications for systems with server-side based on VeriLook Extended SDK. See “VeriLook Embedded SDK” brochure for more information.
- **VeriLook Surveillance SDK** - allows to create software for performing biometric face identification using live video streams from high-resolution digital surveillance cameras. See “VeriLook Surveillance SDK” brochure for more information.
- **MegaMatcher SDK** – intended for development of AFIS or multi-biometric face, fingerprint, iris, voiceprint and palm print identification products. See “MegaMatcher SDK” brochure for more information.
- **MegaMatcher On Card SDK** – a product for fingerprint, iris and face matching on smart cards. See “MegaMatcher On Card SDK” brochure for more information.
- **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

The following 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.

Product Development

An integrator should obtain either a VeriLook 5.2 Standard SDK (EUR 339) or VeriLook 5.2 Extended SDK (EUR 859) to develop a product based on VeriLook technology. The SDK needs to be purchased just once and may be used by all the developers within the integrator's company.

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

VeriLook SDK components and licenses included with a specific SDK		
	VeriLook 5.2 Standard SDK	VeriLook 5.2 Extended SDK
• Face Matcher	1 single computer license	1 single computer license
• Face Client ⁽¹⁾		3 single computer licenses and 1 concurrent license
• Face Extractor	1 single computer license	1 single computer license
• Matching Server		+

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

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 5.2 SDK customers as required by their development process.

Product Deployment

To deploy a product developed with VeriLook 5.0 / 5.1 / 5.2 SDK, an integrator need to obtain only the additional licenses required for the particular VeriLook 5.2 components that will run on **each CPU** of their customer's computers. The available VeriLook components and license types for product deployment are the same as for product development.

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

Prices for VeriLook 5.2 SDK and additional VeriLook component licenses can be found in the next section.

Please refer to the License Agreement on Neurotechnology web site for all licensing terms and conditions.



Single computer licenses

A single computer license allows the installation and running of a VeriLook component installation on one CPU (a processor can have any number of cores). Neurotechnology provides a way to renew the license if the computer undergoes changes due to technical maintenance.

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

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

Concurrent network licenses

Concurrent licenses are available for Face Client component, allowing the installation of this specific component on an unlimited number of computers. An application obtains a specific license for the capturing process and to perform template creation (extraction). On average it takes less than 10 seconds for face capturing/enrolling. After this interval the license is released, making it available for another user. One Face Client concurrent license can be shared among tens of users, making this license especially **useful for web-based** software.

The number of simultaneously running Face Client component instances is limited by the number of concurrent licenses. Available license management options are listed below.

Additional concurrent network licenses may be obtained at any time by VeriLook SDK customers.

License activation options

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

- **Serial numbers** are used to activate licenses for particular VeriLook components. The activation is done via the Internet or by email. After activation the network connection is not required for single computer license usage. Note: activation by serial number is not suitable for virtual environments.
- 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

Volume license manager is used on site by integrators or end users to manage licenses for VeriLook components. It consists of license management software and a dongle, used to store the purchased licenses. An integrator or an end-user may use the volume license manager in the following ways:

- **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.
- **Managing single computer or concurrent licenses via a LAN or the Internet** – The license manager allows the management of installation licenses for VeriLook components across multiple computers 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 on the network.
- **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.

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 5.2 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. VeriLook enterprise licenses are intended for larger projects, with pricing starting at **EUR 20,000**.

VeriLook algorithm **source code** may be included with a special source code licensing agreement for the selected customers, who are going to obtain VeriLook enterprise license for at least EUR 100,000 or more.

For more information please contact us.



Prices for VeriLook 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 SDK

VeriLook 5.2 Standard SDK	€ 339.00
VeriLook 5.2 Extended SDK	€ 859.00

Face Client concurrent licenses

Price per license	€ 390.00
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Face components (prices per single computer license)

Quantity	Face Extractor	Face Client ⁽¹⁾	Face Matcher
1-9	€ 20.00	€ 25.00	€ 25.00
10-19	€ 15.00	€ 18.00	€ 18.00
20-49	€ 13.00	€ 16.00	€ 16.00
50-99	€ 11.00	€ 14.00	€ 14.00
100-199	€ 10.00	€ 12.50	€ 12.50
200-499	€ 9.00	€ 11.00	€ 11.00
500-999	€ 8.00	€ 10.00	€ 10.00
1000-1999	€ 7.00	€ 9.00	€ 9.00
2000-3999	€ 6.40	€ 8.00	€ 8.00
4000-7999	€ 5.80	€ 7.00	€ 7.00
8000 and more	Please contact us for more information		

(1) Face Client component is not available for VeriLook Standard SDK customers.

License management

Volume license manager	€ 16.00
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VeriLook enterprise license

VeriLook 5.2 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