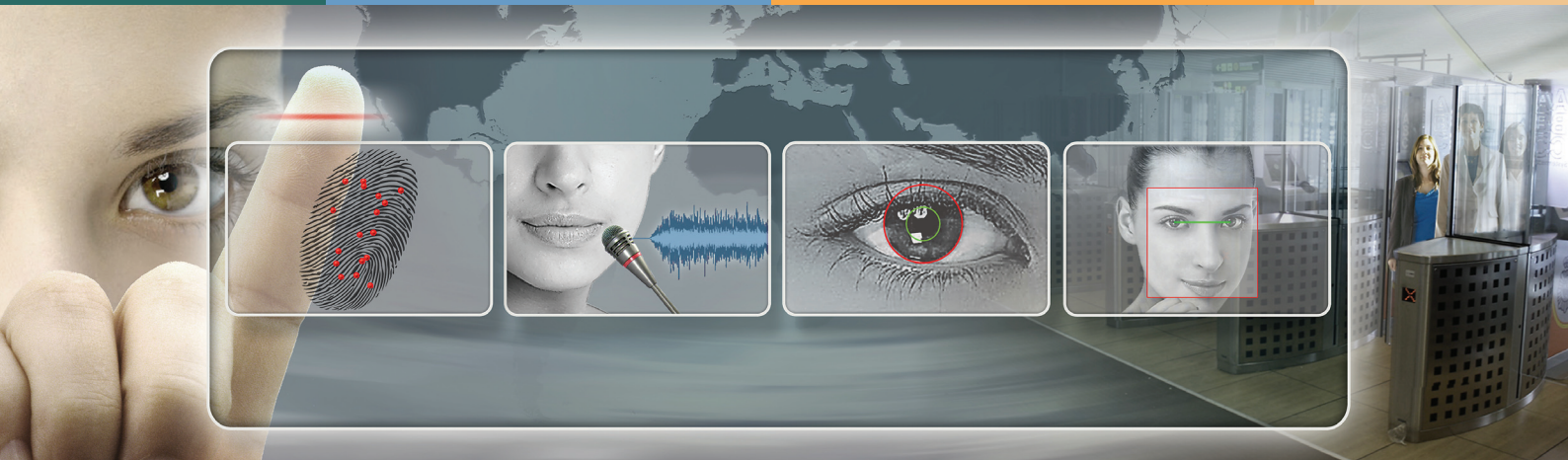




NEUROtechnology



Large-scale
AFIS and
multi-biometric
identification

MegaMatcher SDK



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Large-scale AFIS and multi-biometric identification

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MegaMatcher technology is intended for large-scale AFIS and multi-biometric systems developers. The technology ensures high reliability and speed of biometric identification even when using large databases.

MegaMatcher is available as a software development kit that allows development of large-scale single- or multi-biometric fingerprint, iris, face, voice or palm print identification products for Microsoft Windows, Linux and Mac OS X platforms.

- Proven in national-scale projects, including passport issuance and voter deduplication.
- NIST MINEX-compliant fingerprint engine, NIST IREX proven iris engine.
- Includes fingerprint, iris, face, voice and palm print modalities.
- Rolled, flat and latent fingerprint matching.
- BioAPI 2.0 and other ANSI and ISO biometric standards support.
- Multiplatform, scalable cluster architecture for parallel matching.
- Effective price/performance ratio, flexible licensing and free customer support.



MegaMatcher algorithm features and capabilities

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

MegaMatcher includes fingerprint, facial, speaker, iris and palm print recognition engines along with a new fused algorithm for fast and reliable identification in large-scale systems.

The fingerprint, face, voice and iris identification algorithms may each be used separately to develop AFIS, automated face, speaker or iris identification systems.

The biometric software engines contain many proprietary algorithmic solutions that are especially useful for large-scale identification problems. These solutions were specifically developed for MegaMatcher, incorporating aspects of the VeriFinger, VeriLook, VeriSpeak and VeriEye algorithms. Some of these solutions are listed in the fingerprint, face, voice and iris biometric identification engine descriptions below.

MegaMatcher fingerprint template extraction and matching engine

- **Full MINEX Compliance.** NIST has recognized MegaMatcher fingerprint algorithm as MINEX compliant and suitable for use in personal identity verification (PIV) program applications.
- **Rolled and flat fingerprints matching.** The MegaMatcher fingerprint engine matches rolled and flat fingerprints **between themselves**. Typically, conventional “flat” fingerprint identification algorithms perform matching between flat and rolled fingerprints less reliably due to the specific deformations of rolled fingerprints. MegaMatcher allows flat-to-flat, flat-to-rolled or rolled-to-rolled fingerprint matching with a high degree of reliability and accuracy. The algorithm matches up to 136,000 flat fingerprint records per second.
- MegaMatcher includes fingerprint **image quality determination**, which can be used during enrollment to ensure that only the best quality fingerprint template will be stored in the database.
- **Template generalization** is used to generate a better quality template from several fingerprints. Better quality templates result in a higher level of identification accuracy.
- MegaMatcher is **tolerant to fingerprint translation, rotation and deformation**. It uses a proprietary fingerprint matching algorithm that identifies fingerprints even if they are rotated, translated or have deformations.
- **Adaptive image filtration** algorithm eliminates noises, ridge ruptures and stuck ridges, and reliably extracting minutiae from even the poorest quality fingerprints in less than 1 second.

MegaMatcher face template extraction and matching engine

- **Template generalization** is used to generate a better quality template from several face images. Better quality templates result in higher identification quality.
- **Tolerance to face posture** assures face enrollment convenience. MegaMatcher 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.
- **Reliable face detection** assures convenient face enrollment from cameras, webcams and especially various scanned documents: faces will be found on scanned pages from passports, files etc. **Multiple faces** can be also detected on an image and simultaneously processed.
- **Live face detection.** A conventional face identification system can be easily cheated by placing a photo of another person in front of a camera. MegaMatcher 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.
- The biometric template record can contain **several face samples belonging to the same person**. These samples can be enrolled from different sources and in different time, thus allowing improvement in matching quality. For example a person could be enrolled with and without eyeglasses or with different eyeglasses, with and without beard or moustache, etc.



MegaMatcher voice template extraction and matching engine

- **Text-dependent** voice matching engine determines if a voice sample matches the template that was extracted from a specific phrase. During enrollment, one or more phrases are requested from the person being enrolled. Later that person may be asked to pronounce a specific phrase for verification. This method assures protection against the use of a covertly recorded random phrase from that person.
- **Two-factor authentication with a passphrase** is performed when a person is asked to say a **unique phrase** (such as passphrase or an answer to a “secret question” that is **known only by the person** being enrolled). The overall system security increases as both voice authenticity and password are checked.
- **Liveness detection.** A system may request each user to enroll a set of unique phrases. Later the user will be requested to say a specific phrase from the enrolled set. This way the system can ensure that a live person is being verified (as opposed to impostor who uses voice recording).
- **Several voice records with the same phrase** may be stored to improve speaker recognition reliability. Certain natural voice variations (i.e. hoarse voice) or environment changes (i.e. office and outdoors) can be stored in the same template.

MegaMatcher iris template extraction and matching engine

- **NIST IREX proven reliability.** MegaMatcher iris matching engine is based on VeriEye, that was recognized by NIST in 2009 as one of the most reliably accurate iris recognition algorithms.
- **Fast matching.** Configurable matching speed varies from 60,000 to **920,000 comparisons per second**. See “technical specifications” section for more details.
- **Robust iris detection.** Irises are detected even when the images have obstructions, visual noise and different levels of illumination. Lighting reflections, eyelids and eyelashes obstructions are eliminated. Images with narrowed eyelids or eyes that are gazing away are also accepted.
- **Automatic interlacing detection and correction.** The correction results in maximum quality of iris features templates from moving iris images.
- **Correct iris segmentation** is achieved when perfect circles fail, the centers of the iris inner and outer boundaries are different, iris boundaries are definitely not circles and even not ellipses or iris boundaries seem to be perfect circles.



MegaMatcher and MegaMatcher Accelerator in High Productivity Systems

See also *MegaMatcher Accelerator brochure*.

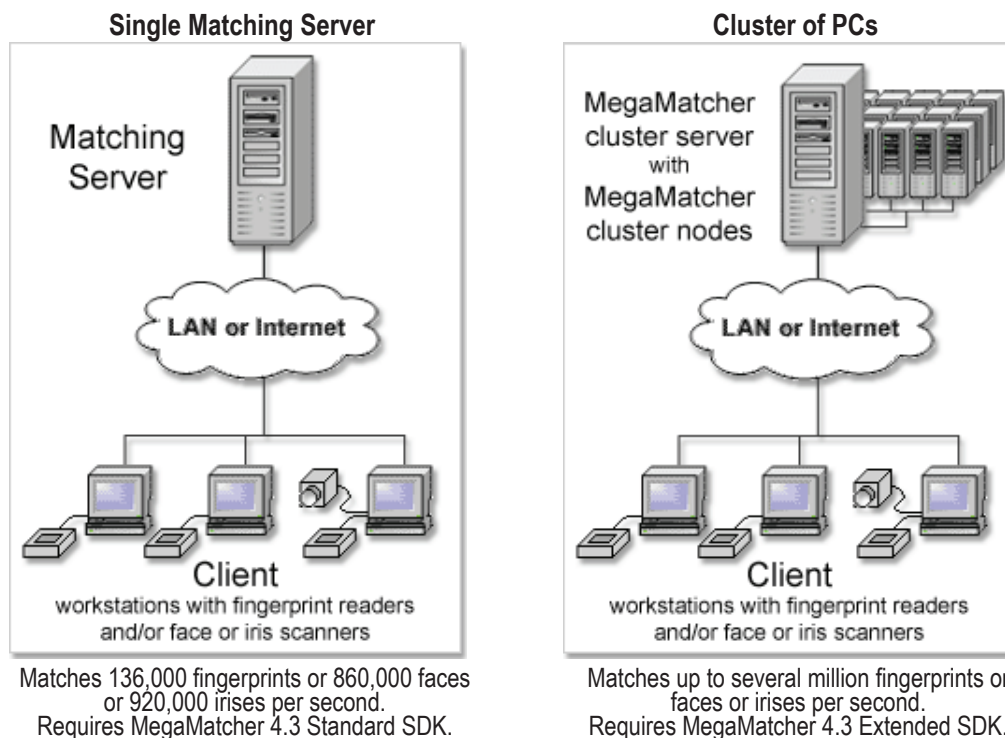
Different AFIS projects may require specific biometric system performance. These matching engines and architectures may be used depending on the required matching speed, database size and system availability:

- Single Matching Server;
- Cluster of PCs running MegaMatcher components;
- Single MegaMatcher Accelerator 4.0 Standard or Extended unit (see “*MegaMatcher Accelerator*” brochure);
- Cluster of MegaMatcher Accelerator 4.0 Standard or Extended units (see “*MegaMatcher Accelerator*” brochure).

It is possible to use more than one architecture within a large-scale biometric system to reach optimal system performance and/or availability. For example, MegaMatcher Accelerator 4.0 unit(s) can be used for candidates selection using irises or several fingerprints, and then the results can be validated on Matching Server or cluster with other biometric modalities. Also, two or more Cluster Servers or MegaMatcher Accelerator 4.0 clusters can be connected together for high availability system.

See Product Advisor at www.neurotechnology.com/product-advisor.html to find out what Neurotechnology products and system architectures will suit your project requirements.

The charts below compare MegaMatcher SDK architectures for high performance AFIS:





Single Matching Server

The architecture with a single Matching Server is intended to be used in moderate size systems like local AFIS or multi-biometric system which do not have strict requirements on performance or availability. The Matching Server software is available in MegaMatcher 4.3 Standard and Extended SDKs, as well as in VeriFinger 6.5 Extended SDK, VeriLook 5.2 Extended SDK, VeriSpeak 1.1 Extended SDK and VeriEye 2.5 Extended SDK.

A PC running Matching Server software accepts identification requests from client-side components for fingerprint, face and/or iris biometrics and returns back the identification results. Up to 136,000 fingerprints or 860,000 faces or 920,000 irises per second can be matched on single Matching Server (on Intel Core 2 Q9400 processor running at 2.67 GHz).

The Matching Server can be also used for multi-biometric systems that use any combination of these biometric modalities: fingerprints, faces, voiceprints and/or irises. See “technical specifications” section for more information on fingerprint, face, voice, iris and fused matching engines performance.

Cluster of PCs running MegaMatcher components

This architecture is designed for high productivity AFIS or multi-biometric system with millions of biometric templates stored in the database. The Cluster Server component is available in MegaMatcher Extended SDK.

Cluster Server distributes identification task over computers connected to the network. A biometric system based on Cluster Server software can be scaled up anytime to meet changing project requirements in increasing user amount or request environment. The cluster software consists of a Cluster Server and software for cluster nodes that run fingerprint, face, voice and/or iris components.

The Cluster Server accepts requests from client side, manages cluster work, distributes tasks over cluster nodes, collects results, reports them back to client side. Also it communicates with the main database which stores the biometric data.

Each cluster node matches up to 136,000 fingerprints or 860,000 faces or 920,000 irises per second (on Intel Core 2 Q9400 processor running at 2.67 GHz). The Cluster Server can be also used for multi-biometric systems that use any combination of these biometric modalities: fingerprints, faces, voiceprints and/or irises. See technical specifications for more information on fingerprint, face, iris, voice and fused matching engines performance.

A cluster node contains part of the main database, performs identification tasks in it and reports results to the Cluster Server. The node must have enough memory to store that database part, as all data is kept in memory during identification to achieve the best matching speed. A larger number of nodes results in faster matching, because each node operates on a smaller part of the database.

The cluster node uses database to store its database part and in order to perform relational queries, such as filter persons by gender, age, living place.



The amount of required cluster nodes is calculated is this way:

1. The whole database should fit into nodes memory (RAM). For example, if there are 10GB of biometric data and each node has 2GB of free memory available, at least 5 nodes should be used as otherwise the database will not fit into nodes memory and the cluster will not work.
2. The identification speed should satisfy project requirements. The speed requirements may be defined indirectly via identification request response time and/or peak hour request quantity with a given database.
 - **Response time.** For example, a database stores biometric data for 1 million people with 2 fingerprints for each of them, and the response time for an identification request should be 1 second. At least 15 cluster nodes should be used to provide the required response time.
 - **Peak hour request quantity.** For example, the project with the same database as above requires to process 5,000 identification requests at the peak hour. At least 21 cluster nodes should be used to provide the required peak hour availability.

These methods of node fault tolerance are implemented in the Cluster Server software:

1. **Spare nodes** (enabled by **default**). A spare node “waits” until an operating node fails and is used to replace the failed one by copying the part of database that was used in the failed node. If the failed node restored, it become the spare node.
2. **Re-split** tasks and database over existing nodes. If a node fails, the system finishes all tasks which are not related with the failed node, reinitializes nodes again by re-splitting the database over them and continues tasks passed into cluster. As a result the overall cluster performance decreases but the cluster continues to operate until the failed node is fixed or replaced. Note, that the database re-split is possible only if total amount of memory available in the remaining nodes is larger than the database size.
3. **Spare Cluster Servers.** A secondary Cluster Server may run within a cluster **synchronized** with the primary Cluster Server. If the primary Cluster Server becomes not available (due to crash or network problems), the secondary one **replaces it on-the-fly** and continues the cluster operation as new primary server. If the failed Cluster Server becomes available some time later, it can synchronize with the operating one and start acting as the new secondary server. There may be more than one spare Cluster Server within the cluster; the spare Cluster Servers will be organized in line, automatically maintain the line and replace the failed primary server in turn.
4. **Parallel Cluster Servers.** A parallel “spare” cluster may be run together with the main cluster and keep the data synchronized between the clusters. If the primary Cluster Server becomes not available, the parallel cluster **replaces on-the-fly** the failed one and keeps serving identification requests.

We recommend to leave at least 10%-20% free memory reserve when calculating the amount of used nodes in a cluster for both fault tolerance methods. The memory reserve would allow to avoid situations when the system can not continue work as it has not enough resources.



Contents of MegaMatcher 4.3 Standard SDK and Extended SDK

MegaMatcher SDK is intended for development of large-scale AFIS or multi-biometric identification products. Fingerprint, face, voice, iris and palm print recognition engines are included in MegaMatcher 4.3 SDK.

MegaMatcher 4.3 SDK includes server-side software and a set of modules for developing client-side applications. .NET components are included for rapid development of client-side software. MegaMatcher 4.3 supports **BioAPI 2.0**. To ensure system compatibility with other software, **WSQ** component is available, as well as modules for conversion between MegaMatcher template and biometric standards.

MegaMatcher 4.3 is suitable not only for developing **civil AFIS**, but also for **forensic AFIS applications**, as it includes an API for **latent fingerprint template editing**. Latent fingerprint template editing is necessary in order to submit a latent fingerprint (for example, one taken from a crime scene) for the identification into AFIS. Also MegaMatcher is able to **match rolled and flat fingerprints between themselves**.

There are these types of MegaMatcher 4.3 SDK:

- **MegaMatcher 4.3 Standard SDK** for developing a client/server based multi-biometric face-fingerprint and optionally iris identification product. This SDK is suitable for **network-based** and **web-based** systems with database size ranging from several thousand records up to million records. The SDK includes ready-to-use server-side software and a set of components for developing client-side applications. Also one or more MegaMatcher Accelerator units or installation licenses can be additionally purchased for building high performance systems that match tens of millions of fingerprints and/or irises per second.
- **MegaMatcher 4.3 Extended SDK** for developing a large-scale network-based AFIS or multi-biometric identification product. The fault-tolerant **scalable cluster** software allows to perform fast parallel matching, processes high number of identification requests and handles databases with practically **unlimited size**. The SDK includes all components of MegaMatcher 4.3 Standard SDK and ready-to-use cluster server and node software. This SDK also allows to develop **network-based** and **web-based** systems.

The Standard and Extended SDKs are compared on the next page.

MegaMatcher 4.3 SDK includes programming samples and tutorials that show how to use the components of the SDK to perform fingerprint, face and iris 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	+		
Programming tutorials			
• C	+	+	+
• C#	+		
• Visual Basic .NET	+		
• Sun Java 2	+	+	+



The table below compares MegaMatcher 4.3 Standard SDK and MegaMatcher 4.3 Extended SDK. See the licensing model for more information on specific license types.

	MegaMatcher 4.3 Standard SDK	MegaMatcher 4.3 Extended SDK
Fingerprint component licenses included with a specific SDK:		
• Fingerprint Matcher	1 single computer license	1 single computer license
• Fast Fingerprint Matcher	1 single computer license	2 single computer licenses
• Fingerprint Client ⁽¹⁾	3 single computer licenses and 1 concurrent license	3 single computer licenses and 1 concurrent license
• Fingerprint Extractor	1 single computer license	1 single computer license
Face component licenses included with a specific SDK:		
• Face Matcher	1 single computer license	1 single computer license
• Fast Face Matcher	1 single computer license	2 single computer licenses
• Face Client ⁽²⁾	3 single computer licenses and 1 concurrent license	3 single computer licenses and 1 concurrent license
• Face Extractor	1 single computer license	1 single computer license
Iris component licenses included with a specific SDK:		
• Iris Matcher	1 single computer license	1 single computer license
• Fast Iris Matcher	1 single computer license	2 single computer licenses
• Iris Client ⁽³⁾	3 single computer licenses and 1 concurrent license	3 single computer licenses and 1 concurrent license
• Iris Extractor	1 single computer license	1 single computer license
Voice component licenses included with a specific SDK:		
• Voice Matcher	1 single computer license	2 single computer licenses
• Voice Client	3 single computer licenses and 1 concurrent license	3 single computer licenses and 1 concurrent license
• Voice Extractor	1 single computer license	1 single computer license
Palm print component licenses included with a specific SDK:		
• Palm Print Matcher	1 single computer license	2 single computer licenses
• Palm Print Client	1 single computer license	1 single computer license
Server and cluster component licenses included with a specific SDK:		
• Matching Server	+	+
• Cluster Server		1 single computer license

Notes:

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

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

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



Fingerprint Components Description

Fingerprint Matcher

The Fingerprint Matcher performs fingerprint template matching in 1-to-1 (verification) and 1-to-many (identification) modes. Also the Fingerprint Matcher component includes fused matching algorithm that allows to increase template matching reliability by:

- matching templates that contain 2 or more fingerprint records (note that Fingerprint Segmenter or Fingerprint Client components are required to perform template extraction from images that contain more than one fingerprint);
- matching templates that contain fingerprint, face, voiceprint and/or iris records (note that matching faces, irises and voiceprints requires Face Matcher, Iris Matcher and Voice Matcher components correspondingly).

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

One Fingerprint Matcher license is included with MegaMatcher 4.3 Standard SDK and MegaMatcher 4.3 Extended SDK. More licenses for this component can be purchased any time by MegaMatcher 4.3 SDK customers.

Fast Fingerprint Matcher

The Fast Fingerprint Matcher component is intended for the large-scale AFIS and biometric systems. The component includes a **fast matching mode** and also has the same matching mode as the regular Fingerprint Matcher.

Multi-biometric fused template matching can be achieved by combining the Fast Fingerprint Matcher component with Face, Voice and/or Iris Matchers (regular or fast versions of them can be used depending on project implementation).

See the “reliability and performance testing results” section for the comparison of matching modes and multi-modal template matching.

One Fast Fingerprint Matcher license is included with MegaMatcher 4.3 Standard SDK. Two Fast Fingerprint Matcher licenses are included with MegaMatcher 4.3 Extended SDK. More licenses for this component can be purchased any time by MegaMatcher 4.3 SDK customers.

Fingerprint Client

The Fingerprint Client component is a combination of the **Fingerprint Extractor**, **Fingerprint BSS**, **Fingerprint Segmenter** and **Fingerprint WSQ** components. It is intended for the systems that need to support most or 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 Fingerprint Client component are included with MegaMatcher 4.3 Standard SDK and MegaMatcher 4.3 Extended SDK. More non-concurrent and concurrent licenses for this component can be purchased any time by MegaMatcher 4.3 SDK customers.



Fingerprint Extractor

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

The Fingerprint Extractor can generalize a fingerprint template from several fingerprint images to improve the template's quality.

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

One Fingerprint Extractor license is included with MegaMatcher 4.3 Standard SDK and MegaMatcher 4.3 Extended SDK. More licenses for this component can be purchased any time by MegaMatcher 4.3 SDK customers.

Fingerprint Segmenter

The Fingerprint Segmenter component separates fingerprints if an image contains more than one fingerprint. This component enables Fingerprint Extractor component to process fingerprints from scanned **tenprint** card or image captured using scanners that allow to scan two or more fingers at once.

The 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.

The Fingerprint Segmenter licenses can be purchased anytime by MegaMatcher 4.3 SDK customers.

Fingerprint WSQ

The Fingerprint WSQ component allows to integrate support for WSQ (Wavelet Scalar Quantization) image format. The WSQ format allows to compress a fingerprint image up to 10-15 times. WSQ compression process is “lossy”, meaning that the reconstructed image is not equal to the original (some information is lost). However, the WSQ algorithm was specially designed to minimize the loss of fingerprint information therefore the reconstructed image is as close as possible to the original.

Neurotechnology's implementation of WSQ 3.1 fingerprint image compression was **certified by the FBI** as compliant with the accuracy requirements in the Wavelet Scalar Quantization (WSQ) Gray-Scale Fingerprint Image Compression Specification, Version 3.1.

The 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 Fingerprint WSQ component can be purchased anytime by MegaMatcher 4.3 SDK customers.



Fingerprint BSS (Biometric Standards Support)

The Fingerprint BSS component allows to integrate support for fingerprint template and image format standards and additional image formats with new or existing biometric systems based on MegaMatcher SDK.

These biometric standards are supported:

- **BioAPI 2.0 (ISO/IEC 19784-1:2006)** (Framework and Biometric Service Provider for fingerprint identification engine)
- **ISO/IEC 19794-2:2005** (Fingerprint Minutiae Data)
- **ISO/IEC 19794-4:2005** (Finger Image Data)
- **ANSI/INCITS 378-2004** (Finger Minutiae Format for Data Interchange)
- **ANSI/INCITS 381-2004** (Finger Image-Based Data Interchange Format)
- **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)

The Fingerprint BSS component allows conversion between Neurotechnology proprietary fingerprint templates, ISO/IEC 19794-2:2005, ANSI/INCITS 378-2004 and ANSI/NIST-ITL templates.

Fingerprint pattern classification module that allows to determine a fingerprint pattern class is included with Fingerprint BSS module. The classification is usually used in forensics, but also it can be used to increase fingerprint matching speed. The defined classes are:

- Left Slant Loop;
- Right Slant Loop;
- Tented Arch;
- Whorl;
- Scar;
- "Unknown" – for the nondetermined classes.

The Fingerprint BSS component also includes:

- JPEG 2000 image format support module with 1000 dpi Fingerprint Profile;
- NIST IHead image format support module;
- module with NIST Fingerprint Image Quality (NFIQ) algorithm, a standard method to determine fingerprint image quality.

Latent Fingerprint Editor is available with Fingerprint BSS component. In most cases automated image processing is unable to extract all minutiae or extracts a lot of false minutiae from latent fingerprint image (for example, taken from the crime scene). Therefore, an expert should manually edit a fingerprint template in order to submit it to an AFIS for the identification.

Sample latent fingerprint template editor (.NET) shows how to change minutia's coordinates, direction, type and other parameters.

The Fingerprint 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 Fingerprint BSS component can be purchased anytime by MegaMatcher 4.3 SDK customers.



Face 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, voiceprints and/or iris records (note that matching fingerprints, irises and voiceprints requires Fingerprint Matcher, Iris Matcher and Voice Matcher components correspondingly).

“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 MegaMatcher 4.3 Standard SDK and MegaMatcher 4.3 Extended SDK. More licenses for this component can be purchased any time by MegaMatcher 4.3 SDK customers.

Fast Face Matcher

The Fast Face Matcher component is intended for the large-scale biometric systems. The component includes a **fast matching mode** and also has the same matching mode as the regular Face Matcher.

Multi-biometric fused template matching can be achieved by combining the Fast Face Matcher component with Fingerprint, Voice and/or Iris Matchers (regular or fast versions of them can be used depending on project implementation).

See the “reliability and performance testing results” section for the comparison of matching modes and multi-modal template matching.

One Fast Face Matcher license is included with MegaMatcher 4.3 Standard SDK. Two Fast Face Matcher licenses are included with MegaMatcher 4.3 Extended SDK. More licenses for this component can be purchased any time by MegaMatcher 4.3 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 MegaMatcher 4.3 Standard SDK and MegaMatcher 4.3 Extended SDK. More non-concurrent and concurrent licenses for this component can be purchased any time by MegaMatcher 4.3 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 MegaMatcher 4.3 Standard SDK and MegaMatcher 4.3 Extended SDK. More licenses for this component can be purchased any time by MegaMatcher 4.3 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 MegaMatcher 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 MegaMatcher 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 MegaMatcher 4.3 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.”*



Voice Components Description

Voice Matcher

The Voice Matcher performs voice template matching in 1-to-1 (verification) and 1-to-many (identification) modes. Also the Voice Matcher component includes fused matching algorithm that allows to increase template matching reliability by matching templates that contain fingerprint, face, voice and/or iris records (note that matching fingerprints, irises and faces requires to purchase Fingerprint Matcher, Iris Matcher and Face Matcher components correspondingly).

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

One Voice Matcher license is included with MegaMatcher 4.3 Standard SDK. Two Voice Matcher licenses are included with MegaMatcher 4.3 Extended SDK. More licenses for this component can be purchased any time by MegaMatcher 4.3 SDK customers.

Voice Client

The Voice Client component currently has the same functionality as Voice Extractor component. It is intended for using on client-side of web-based and network-based biometric systems.

Three non-concurrent licenses and one concurrent license for the Voice Client component are included with MegaMatcher 4.3 Standard SDK and MegaMatcher 4.3 Extended SDK. More non-concurrent and concurrent licenses for this component can be purchased any time by MegaMatcher 4.3 SDK customers.

Voice Extractor

Voice Extractor creates voice templates from audio samples.

See technical specifications for the template extraction speed, the size of voice template and the requirements for voice record.

One Voice Extractor license is included with MegaMatcher 4.3 Standard SDK and MegaMatcher 4.3 Extended SDK. More licenses for this component can be purchased any time by MegaMatcher 4.3 SDK customers.



Iris Components Description

Iris Matcher

The Iris Matcher performs iris template matching in 1-to-1 (verification) and 1-to-many (identification) modes. Also the Iris Matcher component includes fused matching algorithm that allows to increase template matching reliability by:

- matching templates that contain 2 iris records;
- matching templates that contain fingerprint, face, voiceprint and/or iris records (note that matching fingerprints, faces and voiceprints requires Fingerprint Matcher, Face Matcher and Voice Matcher components correspondingly);

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

One Iris Matcher license is included with MegaMatcher 4.3 Standard SDK and MegaMatcher 4.3 Extended SDK. More licenses for this component can be purchased any time by MegaMatcher 4.3 SDK customers.

Fast Iris Matcher

The Fast Iris Matcher component is intended for the large-scale biometric systems. The component includes a fast matching mode and also has the same matching modes as the regular Iris Matcher.

Multi-biometric fused template matching can be achieved by combining the Fast Iris Matcher component with Fingerprint, Face and/or Voice Matchers (regular or fast versions of them can be used depending on project implementation).

See the “reliability and performance testing results” section for the comparison of matching modes and multi-modal template matching.

One Fast Iris Matcher license is included with MegaMatcher 4.3 Standard SDK. Two Fast Iris Matcher licenses are included with MegaMatcher 4.3 Extended SDK. More licenses for this component can be purchased any time by MegaMatcher 4.3 SDK customers.

Iris Client

The Iris Client component is a combination of the Iris Extractor and Iris 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 Iris Client component are included with MegaMatcher 4.3 Standard SDK and MegaMatcher 4.3 Extended SDK. More non-concurrent and concurrent licenses for this component can be purchased any time by MegaMatcher 4.3 SDK customers.



Iris Extractor

Iris Extractor creates iris templates from eye images.

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

One Iris Extractor license is included with MegaMatcher 4.3 Standard SDK and MegaMatcher 4.3 Extended SDK. More licenses for this component can be purchased any time by MegaMatcher 4.3 SDK customers.

Iris BSS (Biometric Standards Support)

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

These biometric standards are supported:

- **BioAPI 2.0** (ISO/IEC 19784-1:2006) (Framework and Biometric Service Provider for iris identification engine)
- **ISO/IEC 19794-6:2005** (Iris Image Data)
- **ANSI/INCITS 379-2004** (Iris Image Interchange Format)

Iris BSS component also allows to integrate **JPEG 2000** image format support into applications based on the MegaMatcher SDK.

The Iris 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 Iris BSS component can be purchased anytime by MegaMatcher 4.3 SDK customers.



Palm print components description

Palm Print Matcher

The Palm Print Matcher component performs palm print template matching in 1-to-1 (verification) and 1-to-many (identification) modes.

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

One license for the Palm Print Matcher component is included in MegaMatcher 4.3 Standard SDK. Two licenses for the Palm Print Matcher component is included in MegaMatcher 4.3 Extended SDK. More licenses for this component can be purchased any time by MegaMatcher 4.3 SDK customers.

Palm Print Client

The Palm Print Client component creates palm print templates from palm images. Also, it allows to integrate support for palm print template and image format standards and additional image formats with new or existing biometric systems based on MegaMatcher SDK.

These biometric standards are supported:

- **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)

The Palm Print Client component allows conversion between Neurotechnology proprietary palm print templates and ANSI/NIST-ITL templates.

The Palm Print Client component also includes:

- **WSQ** (Wavelet Scalar Quantization) image format support module. The WSQ format allows to compress a palm print image up to 10-15 times. WSQ compression process is “lossy”, meaning that the reconstructed image is not equal to the original (some information is lost). However, the WSQ algorithm was specially designed to minimize the loss of palm print or fingerprint information therefore the reconstructed image is as close as possible to the original.
- **JPEG 2000** image format support module.

The Palm Print Client component can be used from **C/C++** and **C#** applications on all supported platforms. **.NET** wrappers of Windows libraries are provided for **.NET** developers.

See “technical specifications” section for the template extraction speed and the size of palm print template.

One license for the Palm Print Client component is included in MegaMatcher 4.3 Standard SDK and MegaMatcher 4.3 Extended SDK. More licenses for this component can be purchased any time by MegaMatcher 4.3 SDK customers.



Server and Cluster Components Description

Cluster Server

Cluster Server component allows to scale-up a biometric identification system to multiple PCs (cluster nodes) that are linked together via LAN or Internet. The Cluster Server splits the biometric templates database and distributes it between cluster nodes. Each cluster node performs the actual template matching within its own part of the database using:

- Fast Fingerprint Matcher or Fingerprint Matcher component for fingerprint template matching;
- Fast Face Matcher or Face Matcher component for face template matching;
- Fast Iris Matcher or Iris Matcher component for iris template matching.
- Voice Matcher component for voice template matching.

A larger number of nodes results in faster matching, because each node operates on a smaller part of the database. A cluster node can store templates using a database, or using RAM for achieving better performance.

Cluster Server component can be used on Microsoft Windows, Linux and Mac OS X platforms. See system requirements for more information on recommended hardware configuration.

Software for running cluster nodes is also included together with Cluster Server. The cluster node software can be run on unlimited numbers of machines that are connected to the Cluster Server.

Client communication module that allows sending a task to the Cluster 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 Cluster Server component are listed in the table below. Custom modules for working with other databases can also be developed by integrator and used with Cluster Server components.

Component	Microsoft Windows 32-bit & 64-bit	Linux 32-bit & 64-bit	Mac OS X
• Cluster Server software	+	+	+
• Cluster administrating software	+	+	+
• Software for a cluster node	+	+	+
• Microsoft SQL Server support module	+		
• Oracle database support module	+	+	
• MySQL database support module	+	+	+
• SQLite database support module	+	+	+
• PostgreSQL database support module	+	+	

One Cluster Server component license is included with MegaMatcher 4.3 Extended SDK. More licenses for this component can be purchased any time by MegaMatcher 4.3 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 AFIS 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:

- Fast Fingerprint Matcher or Fingerprint Matcher component for fingerprint template matching;
- Fast Face Matcher or Face Matcher component for face template matching;
- Fast Iris Matcher or Iris Matcher component for iris template matching.
- Voice Matcher component for voice template matching.

Fused multi-biometric matching can be enabled by running components for fingerprint, face, voiceprint 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 MegaMatcher 4.3 Standard SDK and MegaMatcher 4.3 Extended SDK.

Also the Matching Server component is included with VeriFinger 6.5 Extended SDK, VeriLook 5.2 Extended SDK, VeriSpeak 1.1 Extended SDK and VeriEye 2.5 Extended SDK (see their brochures for more info).



Supported Fingerprint Scanners under Microsoft Windows

List of fingerprint scanners supported by MegaMatcher SDK under Linux and Mac OS X is available on the next page.

	Windows XP		Windows Vista		Windows 7	
	32-bit	64-bit	32-bit	64-bit	32-bit	64-bit
• ACS AET62 / AET65	+		+	+	+	+
• ARH AFS 510	+		+	+	+	+
• Atmel FingerChip	+					
• Athena ASEDive IIIe Combo Bio F2	+	+	+	+	+	+
• AuthenTec AES4000 / AES2501B / AES2550 / AES2660 / AES2810	+		+	+	+	+
• BioLink U-Match MatchBook v.3.5	+		+			
• Biometri-CS CS-Pass	+		+	+	+	+
• Biometrika Fx2000 / Fx3000	+		+			
• Biometrika HiScan	+					
• Cross Match L SCAN 500P / Guardian / Verifier 300 / 310 / 320	+	+	+	+	+	+
• Digent FD1000	+					
• DigitalPersona U.are.U 2000	+		+			
• DigitalPersona U.are.U 4000 / 4500	+	+	+	+	+	+
• Fujitsu MBF200	+					
• Futronic FS50 / FS80 / FS82 / FS88 / FS90 / eFAM	+	+	+	+	+	+
• Futronic FS60	+		+		+	
• Green Bit DactyScan26 / DactyScan84n	+		+		+	
• Hongda S500 / S680 / S700	+		+			
• id3 Certis Image	+					
• Intech SOP1	+					
• Integrated Biometrics LES650	+	+	+	+	+	+
• Jstac Athena 210	+					
• Koehlke KIAU-5110B3 / KIA-UM01	+		+		+	
• L-1 DFR 2080 / DFR 2090	+		+		+	
• L-1 DFR 2100 / DFR 2300	+		+	+	+	+
• Lumidigm Mercury / Venus Series sensors	+	+	+	+	+	+
• NITGEN Fingkey Hamster / Fingkey Hamster II / Fingkey Mouse III / eNBioScan-F	+	+	+	+	+	+
• SecuGen Hamster III / Hamster Plus / Hamster IV / iD-USB SC / iD-USB SC/PIV	+	+	+	+	+	+
• Shanghai Fingertech BIOCA-111	+		+		+	
• Suprema BioMini / BioMini Plus / SFR300-S / SFU300	+		+	+	+	+
• Suprema RealScan-G10 / RealScan-10 / RealScan-D / RealScan-S	+		+		+	
• Tacoma CMOS	+		+			
• Testech Bio-i	+		+			
• TST Biometrics BiRD 3	+		+			
• UPEK Eikon / Eikon Solo / Eikon To Go / EikonTouch 300/700 / TCRU1C / TCRU2C	+		+		+	
• ViRDI FOH02SC	+		+		+	
• VistaMT Multimodal Biometric Device ⁽¹⁾	+	+	+	+	+	+
• ZKSoftware ZK4000 / ZK6000 / ZK7000 / ZK8000	+		+		+	
• ZKS-1000	+					
• Zvetco Verifi P4000	+		+	+	+	+

(1) The list of supported OS is given only for fingerprint scanner part of the device; the device is also able to capture faces and irises.



Supported Fingerprint Scanners under Linux and Mac OS X

List of fingerprint scanners supported by MegaMatcher SDK under Microsoft Windows is available on the previous page.

	Linux		Mac OS X (x86)	
	32-bit	64-bit	32-bit	64-bit
• ACS AET62 / AET65	+	+	+	+
• ARH AFS 510	+	+		
• Athena ASEDive IIIe Combo Bio F2	+	+		
• BioLink U-Match MatchBook v.3.5	+			
• DigitalPersona U.are.U 4000 / 4500	+	+		
• Fujitsu MBF200	+	+	+	+
• Futronic FS50 / FS80 / FS82 / FS88 / FS90	+		+	+
• Futronic eFAM	+	+	+	+
• Integrated Biometrics LES650	+			
• Lumidigm Mercury / Venus series sensors	+			
• NITGEN eNBioScan-F	+			
• SecuGen Hamster III	+			
• Suprema BioMini / BioMini Plus / SFR300-S / SFU300	+			
• Tacoma CMOS	+	+	+	+
• UPEK Eikon / Eikon Solo / Eikon To Go / EikonTouch 300 / 700 / TCRU1C / TCRU2C	+	+		



Supported Face Capture Cameras

These cameras are supported by MegaMatcher SDK:

- 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 & 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 **plug-ins to support their cameras** using the plug-in framework provided with the Device Manager from the MegaMatcher SDK.

A **video file** can be also used as a data source for face capture on MegaMatcher based application.

Supported Iris Capture Cameras

The table below explains which eye iris scanners are supported by MegaMatcher 4.3 SDK under different versions of Microsoft Windows.

We are always looking for scanners' manufacturers to include the support for their iris scanners to our products. Please, contact us for more details.

Integrators or scanner manufacturers can also write plug-ins for the Device Manager from the MegaMatcher SDK to support their iris cameras using the provided plug-in framework. The SDK documentation contains more information about the plug-in framework.

Iris capture cameras	Microsoft Windows XP		Microsoft Windows Vista		Microsoft Windows 7	
	32 bit	64 bit	32 bit	64 bit	32 bit	64 bit
• Cross Match I Scan 2	+		+			
• IrisGuard IG-AD100 iris & face camera	+		+		+	
• VistaFA2 / VistaFA2E / VistaEY2 iris & face cameras	+	+	+	+	+	+
• VistaMT Multimodal Biometric Device	+	+	+	+	+	+



Basic Recommendations for Facial Recognition

Face recognition accuracy of MegaMatcher 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 MegaMatcher 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.



Basic Recommendations for Speaker Recognition

The speaker recognition accuracy of MegaMatcher depends on the audio quality during enrollment and identification. Certain constraints should be noted before or during algorithm integration into a speaker recognition system, whereas other can be overcome by enrollment with the same phrase in different environments.

At least 2-seconds long voice records are recommended to assure recognition quality.

General Security

A **passphrase should be kept in secret and not pronounced in an environment where other people may hear it** if the speaker recognition system is used in a scenario with unique phrases for each user.

Microphones

There are no particular constraints on models or manufacturers when using regular PC microphones, headsets or built-in laptop microphones. However these factors should be noted:

- The **same microphone model** is recommended (if possible) for use during both enrollment and recognition, as different models can produce different sound quality. Also some models may introduce specific noise or distortion into the audio, or may include certain hardware sound processing, which will not be present when using a different model.
- The same **microphone position** and distance is recommended during enrollment and recognition. **Headsets** provide optimal distance between user and microphone; this distance is recommended when non-headset microphones are used.
- **Web cam built-in** microphones should be **used with care**, as they are usually positioned at a rather long distance from the user and may provide lower sound quality. The sound quality may be affected if users change their position relative to the web cam.

Sound Settings

Settings for clear sound must be ensured, as some audio software, hardware or drivers may have certain means of sound modification **enabled by default**. For example, the Microsoft Windows OS usually has sound boost enabled by default.

At least 11,025 Hz sampling rate with at least **16-bit** depth should be set during voice recording.



Environment Constraints

The MegaMatcher speaker recognition algorithm is sensitive to **background noise** or **loud voices** in the background that may **interfere** with the user's voice and affect the recognition results. These solutions may be considered to reduce or eliminate these problems:

- A **silent environment** for enrollment and recognition.
- **Several samples of the same phrase** recorded in different environments can be stored in a biometric template. Later the user will be matched against these samples with much higher recognition quality.
- **Close-range microphones** (like those in headsets) that are not affected by distant sources of sound.
- Third-party or custom solutions for background noise reduction, like using two separate microphones for recording user voice and background sound, and later subtracting the background noise from the recording.

User Behavior and Voice Changes

These natural voice changes do not occur often but may affect speaker recognition accuracy:

- A temporarily **hoarse voice** caused by a cold or other sickness
- Different **emotional states** that affect voice (i.e. cheerful voice versus tired voice)
- Different **pronunciation speeds** during enrollment and identification

The aforementioned voice and user behavior changes can be managed in two ways:

- **Separate enrollments** for the altered voice with storing the records to the same person's template;
- **Controlled neutral voice** during enrollment and identification.



System Requirements and Supported Development Environments

System Requirements for MegaMatcher client-side components

- **PC or Mac with x86 (32-bit) or x86-64 (64-bit) compatible processors.** 2 GHz processor or better is recommended, as template creation time directly depends on CPU speed.
On one core of Intel Core 2 Q9400 running at 2.67 GHz it takes:
 - 0.19 - 0.23 seconds for fingerprint template creation from an image captured with AFIS class single finger scanner;
 - 0.07 - 0.19 seconds for face template creation;
 - 0.10 - 0.12 seconds for iris template creation;
 - 0.12 - 0.15 seconds for voiceprint template creation;
 - about 6.8 seconds for palm print template creation;
 - 0.1-0.2 seconds for WSQ compression/decompression.
- **at least 128 MB of free RAM** should be available for the application.
- **Free space on hard disk drive (HDD):**
 - at least 1 GB required for the development.
 - 100 MB for client-side components deployment.
 - Additional space optionally would be required in these cases:
 - MegaMatcher does not require the original biometric data (such as fingerprint image or photo) to be stored for the matching; it is enough to use the templates. However, we would recommend to store this data on hard drive for the potential future usage.
 - Usually a database engine runs on back-end servers (on separate computer). However, DB engine can be installed together with MegaMatcher client-side components and Matching Server on the same computer for standalone applications. In this case more HDD space for biometrical templates storage must be available. For example, 1 million users templates (each with 2 fingerprint records) stored using a relational database would require about 2 GB of free HDD space.
- **Optionally, depending on biometrical modalities and requirements:**
 - A **fingerprint scanner**. MegaMatcher SDK includes support modules for more than 80 models of fingerprint scanners under Microsoft Windows, Linux and Mac OS X platforms.
 - A **webcam or camera** (recommended frame size: 640 x 480 pixels) for face images capturing. MegaMatcher SDK includes support modules for several cameras. Any other webcam or camera should provide DirectShow interface for Windows platform or GStreamer interface for Linux platform or QuickTime interface for Mac platform.
 - An **iris camera** (recommended image size: 640 x 480 pixels) for iris image capture. MegaMatcher SDK includes support modules for several iris cameras.
 - A **microphone**. Any microphone that is supported by the operation system can be used.
 - An **palm print scanner**.
 - A **flatbed scanner** for fingerprint or palm print data capturing from paper can be used. 500dpi or 1000dpi FBI certified scanners are recommended. Flatbed scanners are supported only under Microsoft Windows platform and should have TWAIN drivers.
 - Integrators can also write **plug-ins to support their biometric capture devices** using the plug-in framework provided with the Device Manager from the MegaMatcher SDK.



- **Network/LAN connection (TCP/IP)** for communication with Matching Server, Cluster Server or MegaMatcher Accelerator unit(s). MegaMatcher client-side components can be used without network if they are used only for data collection. For secure communication we would recommend to use a dedicated network or a secured network (such as VPN; VPN must be configured using operating system or third party tools).
- **Linux specific requirements:**
 - Linux 2.6 or newer kernel, 32-bit or 64-bit. If a fingerprint scanner is required, note that a number of scanners are supported only on 32-bit OS.
 - glibc 2.7 or newer
 - 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)
 - GStreamer 0.10.23 (with gst-plugin-base and gst-plugin-good) or newer (for face and voice capture using camera/webcam and/or microphone)
 - libasound 1.0.x or newer (for voice capture)
 - udev-143 or newer with libudev (for camera and microphone usage)
 - pkg-config-0.21 or newer (optional; only for database engines support modules compilation)
- **Microsoft Windows specific requirements:**
 - Microsoft Windows XP / Vista / 7, 32-bit or 64-bit. If a fingerprint scanner is required, note that a number of scanners are supported only on 32-bit OS.
 - Microsoft .NET framework 2.0 (for .NET components usage)
 - Microsoft Visual Studio 2005 SP1 or newer (for application development)
 - Microsoft DirectX 9.0 or later (for face capture using camera/webcam)
- **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)



System requirements for Matching Server

- **PC or server with x86 (32-bit) or x86-64 (64-bit) compatible processor.**
 - 64-bit platform must be used when large databases (more than 2.5 million fingerprints or more than 580,000 users with 2 fingerprints and 1 face enrolled) used and 3 GB RAM is not enough for templates storing in RAM.
 - Intel Core 2 (2.66 GHz) processor or better is recommended.
 - Computer with processors that have **two or more cores** can run more than one instance of MegaMatcher matching components (see also “licensing model” section). In this case the memory and disk requirements for the computer should be multiplied by the number of running matching components.
- **Enough free RAM** to store Matching Server code (about 5 MB), matching engines and templates. For example, 1 million users templates (each with 2 fingerprint records) require about 2 GB of RAM. At least 20% reserve recommended and some additional memory may be taken by an operating system. Therefore **to hold mentioned 1 million users data, 3 GB of free RAM is recommended** for the computer running Matching Server software.
- **Free space on hard disk drive (HDD):**
 - 5 MB required for Matching Server software.
 - If a database engine is installed on the same computer, enough HDD space for DB engine installation and data storage is required. For example, 1 million users templates with 2 fingerprint records stored using a relational database would require about 2.2 GB of free HDD space.
 - A database engine itself requires HDD space for running. Please refer to HDD space requirements from the database engine providers.
 - For example, 1 million users templates with 10 fingerprint records and 1 face record stored using a relational database would require about 15 GB of free HDD space.
 - MegaMatcher does not require the original biometric data (such as fingerprint image or photo) to be stored for the matching; it is enough to use the templates. However, we would recommend to store this data on hard drive for the potential future usage.
- **Database engine** or connection with it. Usually a DB engine required for the Matching Server is running on the same computer. MegaMatcher SDK contains support modules for Microsoft SQL Server (only for Microsoft Windows platform), PostgreSQL, MySQL, Oracle, SQLite and memory DB. The fastest option is memory DB but it does not support relational queries, therefore the recommended option is SQLite, as it requires less resources than other options but provides enough functionality.
- **Network/LAN connection (TCP/IP)** for the communication with client side. Communication is not encrypted therefore, if communication must be secured, we would recommend to use 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).
- **Linux specific requirements:**
 - Linux 2.6 or newer kernel, 32-bit or 64-bit.
 - glibc 2.7 or newer
- **Microsoft Windows specific requirements:**
 - Microsoft Windows XP / Vista / 7 / Server 2003 / Server 2008, 32-bit or 64-bit.



System requirements for MegaMatcher cluster nodes

Similar or even exactly the same hardware configuration is recommended for all cluster node machines, as even one slow node will affect the performance of the whole cluster.

- **PC or server with x86 (32-bit) or x86-64 (64-bit) compatible processor.**
 - 64-bit platform must be used when large databases (more than 2.5 million fingerprints or more than 580,000 users with 2 fingerprints and 1 face enrolled) used and 3 GB RAM is not enough for templates storing in RAM.
 - Intel Core 2 (2.66 GHz) processor or better is recommended.
 - Computer with processors that have **two or more cores** can run more than one instance of MegaMatcher matching components (see also “licensing model” section). In this case the memory and disk requirements for the computer should be multiplied by the number of running matching components.
- **Enough free RAM** to store cluster node code (about 5 MB), matching engines and templates. For example, 1 million users templates (each with 2 fingerprint records) require about 2 GB of RAM. At least 20% reserve recommended and some additional memory may be taken by an operating system. Therefore **to hold mentioned 1 million users data, 3 GB of free RAM is recommended** for the computer running cluster node software.
- **Free space on hard disk drive (HDD):**
 - 5 MB required for cluster node software.
 - If a database engine is installed on the same computer, enough HDD space for DB engine installation and data storage is required. For example, 1 million users templates with 2 fingerprint records stored using a relational database would require about 2.2 GB of free HDD space.
 - A database engine itself requires HDD space for running. Please refer to HDD space requirements from the database engine providers.
 - For example, 1 million users templates with 10 fingerprint records and 1 face record stored using a relational database would require about 15 GB of free HDD space.
 - MegaMatcher does not require the original biometric data (such as fingerprint image or photo) to be stored for the matching; it is enough to use the templates. However, we would recommend to store this data on hard drive for the potential future usage.
- **Database engine** or connection with it. Usually a DB engine required for the Matching Server is running on the same computer. MegaMatcher SDK contains support modules for Microsoft SQL Server (only for Microsoft Windows platform), PostgreSQL, MySQL, Oracle, SQLite and memory DB. The fastest option is memory DB but it does not support relational queries, therefore the recommended option is SQLite, as it requires less resources than other options but provides enough functionality.
- **Network/LAN connection (TCP/IP)** for the communication with Cluster Server. Communication is not encrypted therefore, if communication must be secured, we would recommend to use 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).
- **Linux specific requirements:**
 - Linux 2.6 or newer kernel, 32-bit or 64-bit.
 - glibc 2.7 or newer
- **Microsoft Windows specific requirements:**
 - Microsoft Windows XP / Vista / 7 / Server 2003 / Server 2008, 32-bit or 64-bit.



System requirements for Cluster Server

- **PC or server with x86 (32-bit) or x86-64 (64-bit) compatible CPU.** 2 GHz processor or better is recommended. The Cluster Server distributes identification tasks over cluster nodes, performs cluster work monitoring, collects results and reports results to the client side. Computer speed for the Cluster Server is not critical but the computer must be **as much stable as possible**.
- **Enough free RAM** for Cluster Server code (about 5 MB), ongoing tasks and results. For example, 1,000 matching tasks each with 2 fingerprint records would require about 3 MB of RAM.
- **Free space on hard disk drive (HDD):**
 - 5 MB required for Cluster Server software.
 - Up to 2 MB required for saving server state.
 - If a database engine is installed on the same computer, enough HDD space for DB engine installation and data storage is required. For example, 1 million users templates (each with 2 fingerprint records) stored using a relational database would require about 2.2 GB of free HDD space.
- **Database engine (optional).** A connection to a database engine running on a different computer can be provided or the engine can be installed on the same computer with the Cluster Server. MegaMatcher SDK contains support modules for Microsoft SQL Server (only for Microsoft Windows platform), PostgreSQL, MySQL, Oracle and SQLite. SQLite is recommended only for development or evaluation purposes.
- **Network/LAN connection (TCP/IP)** for the communication with Cluster Nodes and client side. Communication is not encrypted therefore if communication must be secured, we would recommend to use 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).
- **Linux specific requirements:**
 - Linux 2.6 or newer kernel, 32-bit or 64-bit.
 - glibc 2.7 or newer
- **Microsoft Windows specific requirements:**
 - Microsoft Windows XP / Vista / 7 / Server 2003 / Server 2008, 32-bit or 64-bit.



Technical Specifications

Fingerprint, Face, Voiceprint and Iris Engines Technical Specifications

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

- Fingerprint scanners are recommended to have at least **500 dpi** resolution and at least **1" x 1"** fingerprint sensors. The specifications are provided for 500 x 500 pixels fingerprint images and templates extracted from these images.
- Face capture cameras are recommended to produce at least **640 x 480 pixels** images for reliable faces' detection. Face template extraction and matching speed is not dependent on the image size.
- The **minimal distance between eyes is 50 pixels** for a face on image or video stream to perform face template extraction. **75 pixels or more recommended** for better template extraction results.
- 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.
 - head **yaw** (bobble) – ± 45 degrees from frontal position. **± 15 degrees default** value is the fastest setting which is usually sufficient for most near-frontal face images.

The specifications are provided for the default roll and yaw values.

- Iris capture cameras are recommended to produce at least **640 x 480 pixels** images. The specifications are provided for these images.
- **At least 2-second long voice samples are recommended** to assure speaker recognition quality.
- **At least 11,025 Hz** sampling rate with at least **16-bit** depth should be configured during voice recording.

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

MegaMatcher biometric template matching algorithm can be run on 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 **4 processor cores**. The specifications are provided for these processors:

- Intel **Core 2 9400** (4 cores), running at **2.67 GHz** clock rate;
- Intel **Core i7-2600** (4 cores), running at **3.4 GHz** clock rate.



MegaMatcher 4.3 fingerprint template extraction and matching engine specifications

	Intel Core 2 Q9400		Intel Core i7-2600	
	Maximized matching accuracy	Maximized matching speed	Maximized matching accuracy	Maximized matching speed
Template extraction time (seconds)	0.20 - 0.25		0.12 - 0.15	
Template matching speed ⁽¹⁾ with $\pm 45^\circ$ fingerprint rotation tolerance (fingerprints per second)	19,000 - 76,000	34,000 - 136,000	38,500 - 154,000	70,000 - 280,000
Template matching speed ⁽¹⁾ with $\pm 90^\circ$ fingerprint rotation tolerance (fingerprints per second)	15,000 - 60,000	27,000 - 108,000	31,000 - 124,000	55,000 - 220,000
Template matching speed ⁽¹⁾ with $\pm 180^\circ$ fingerprint rotation tolerance (fingerprints per second)	11,000 - 44,000	20,000 - 80,000	22,500 - 90,000	41,000 - 164,000
Single fingerprint record size in a template ⁽²⁾ (bytes)	700 - 6,000 (configurable)			

MegaMatcher 4.3 face template extraction and matching engine specifications

	Intel Core 2 Q9400		Intel Core i7-2600	
	Maximized matching accuracy	Maximized matching speed	Maximized matching accuracy	Maximized matching speed
Template extraction time (seconds)	0.19	0.07	0.11	0.04
Template matching speed ⁽¹⁾ (faces per second)	12,000 - 48,000	215,000 - 860,000	30,000 - 120,000	525,000 - 2,100,000
Single face record size in a template ⁽²⁾ (bytes)	35,994	4,026	35,994	4,026

MegaMatcher 4.3 iris template extraction and matching engine specifications

	Intel Core 2 Q9400		Intel Core i7-2600	
	Maximized matching accuracy	Maximized matching speed	Maximized matching accuracy	Maximized matching speed
Template extraction time (seconds)	0.10 - 0.12		0.08 - 0.10	
Template matching speed ⁽¹⁾ with $\pm 15^\circ$ iris rotation tolerance (irises per second)	60,000 - 240,000	230,000 - 920,000	130,000 - 520,000	550,000 - 2,200,000
Template matching speed ⁽¹⁾ with $\pm 30^\circ$ iris rotation tolerance (irises per second)	35,000 - 140,000	175,000 - 700,000	70,000 - 280,000	350,000 - 1,400,000
Single iris record size in a template ⁽²⁾ (bytes)	2,328			

MegaMatcher 4.3 voiceprint template extraction and matching engine specifications⁽³⁾

	Intel Core 2 Q9400		Intel Core i7-2600	
	Fixed phrase	Unique phrase	Fixed phrase	Unique phrase
Template extraction time (seconds)	0.12 - 0.15		0.08 - 0.10	
Template matching speed ⁽¹⁾ (voiceprints per second)	230 - 920	140 - 560	450 - 1,800	250 - 1,000
Single voiceprint record size in a template ⁽²⁾ (bytes)	4,500 - 5,000			

Notes:

- (1) The speeds are given for a single PC with the specified processor. If a cluster is used, the speeds should be multiplied by the number of cluster nodes.
- (2) MegaMatcher 4.3 allows to store multiple biometric records of the same or different biometric modalities in a template; in this case the template size is the sum of all included biometric records.
- (3) The specifications are provided for 5-second long voice samples; template size and template extraction speed have linear dependence from voice sample length, template matching speed has quadratic dependence from voice sample length.



Palm Print Engine Technical Specifications

Palm print template extraction and matching require much more time than fingerprints, as palm images are much larger compared to fingerprint images, but have similar features density.

An image of fingerprint, which was scanned with AFIS-class scanner at 500 dpi resolution, is usually at least 500 x 500 pixels (0.25 Megapixels). Full palm image, scanned at the same resolution, is 160 times bigger (40 Megapixels). After excluding white space, palm image is still about 50 times bigger than fingerprint image. Also, full palm print templates may contain about 2,000 minutiae compared to about 50 for fingerprint templates.

MegaMatcher palm print template matching algorithm can use more than one processor core on **multi-core processors** allowing to increase template matching speed. The template extraction algorithm can be also run on more than one processor core allowing to process several templates in parallel.

MegaMatcher palm print identification algorithm has this performance when processing full palm prints on a single PC with Intel Core 2 Q9400 processor running at 2.67 GHz clock rate:

- Template extraction time: 6.8 seconds;
- Template matching time:
 - 3 templates per second (using 1 processor core);
 - 12 templates per second (using 4 processor cores).
- Average template size: 69 kilobytes.



Full palm print;
fingerprints marked
in red for reference



Reliability and Performance Tests Results

The identification reliability and speed are important for large-scale systems. MegaMatcher SDK includes a fused algorithm for fast and reliable identification using several biometric records taken from the same person.

As we do not have any single database with all supported biometric modalities, separate tests with selected modalities were performed for the MegaMatcher biometric engines to demonstrate their reliability and performance with single biometric modalities and combinations of several modalities:

- Single modality engines tests with publicly available databases
- Fingerprint, face and iris engines tests with internal multi-modal database
- Voiceprint and face engines with XM2VTS database
- Palm print engine

Single Modality Engines Tests

These reliability tests show the MegaMatcher 4.3 fingerprint, face, iris and voiceprint single modality engines performance and reliability. The tests were performed with these publicly available databases:

Biometric databases used for MegaMatcher 4.3 single modality engines tests			
Database	Subset criteria	Records in subset	Unique persons
SONATEQ Fingerprint Database SQ FDB1-75TS1	Only left index fingerprints	7,500	1,500
ND-IRIS-0405 Iris Image Dataset	All iris images	64,980	356
XM2VTS face and voice database	All face images	2,360	295
	Only <i>phrase 1</i> voice samples	2,360	295

The biometric engines had these parameters set:

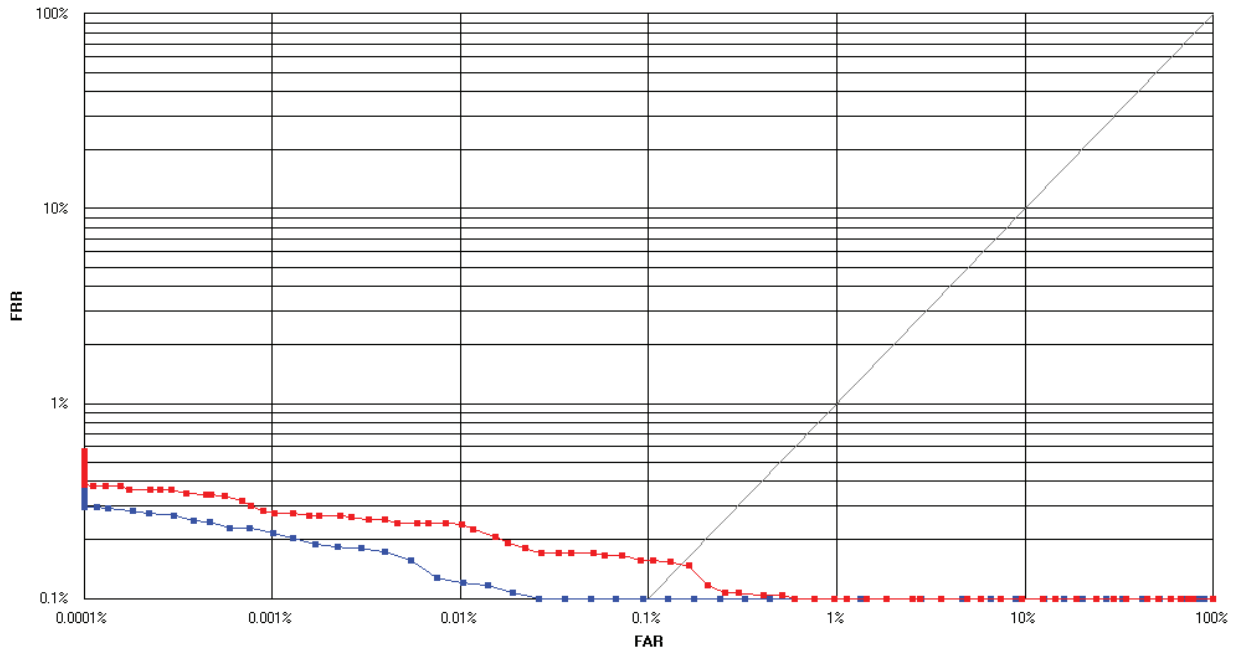
- **±90 degrees fingerprint rotation tolerance** value was used for template matching;
- **±15 degrees iris rotation tolerance** value was used for template matching.

These tests were performed with the biometric database:

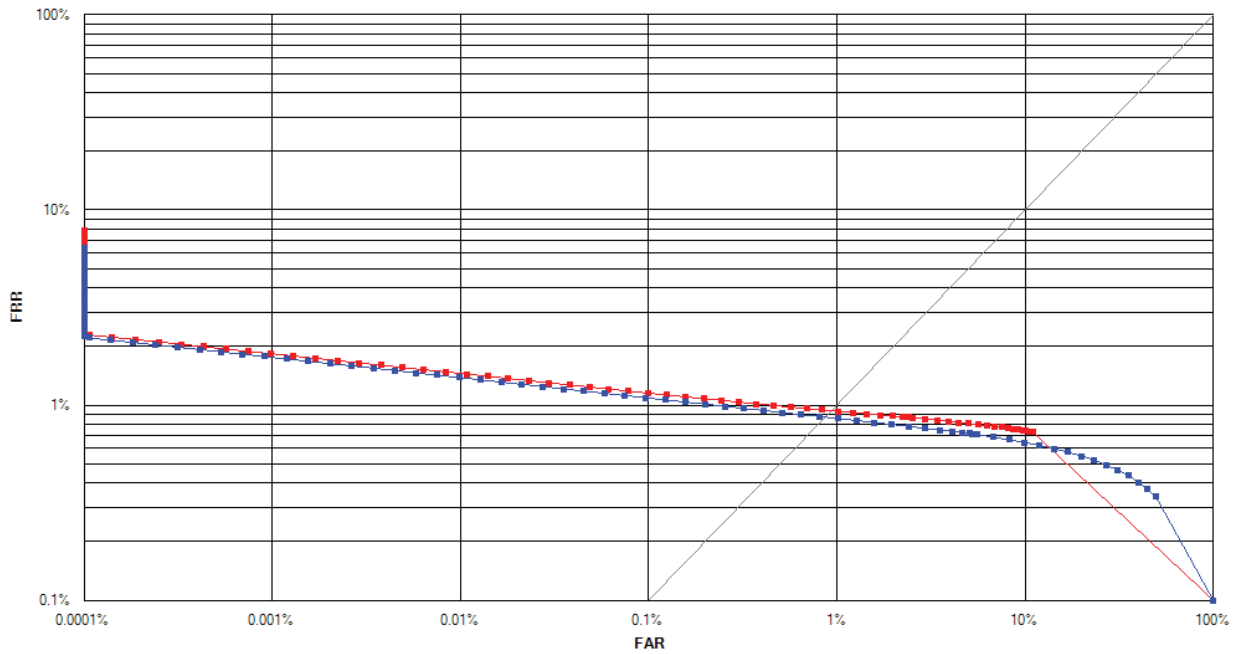
- **Test 1 maximized matching accuracy.** The test was performed only with fingerprint, face and iris databases. MegaMatcher 4.3 fused algorithm reliability in this test is shown as **blue curves** on the ROC charts.
- **Test 2 maximized matching speed.** The test was performed only with fingerprint, face and iris databases. MegaMatcher 4.3 fused algorithm reliability in this test is shown as **red curves** on the ROC charts.

Receiver operation characteristics (**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**).

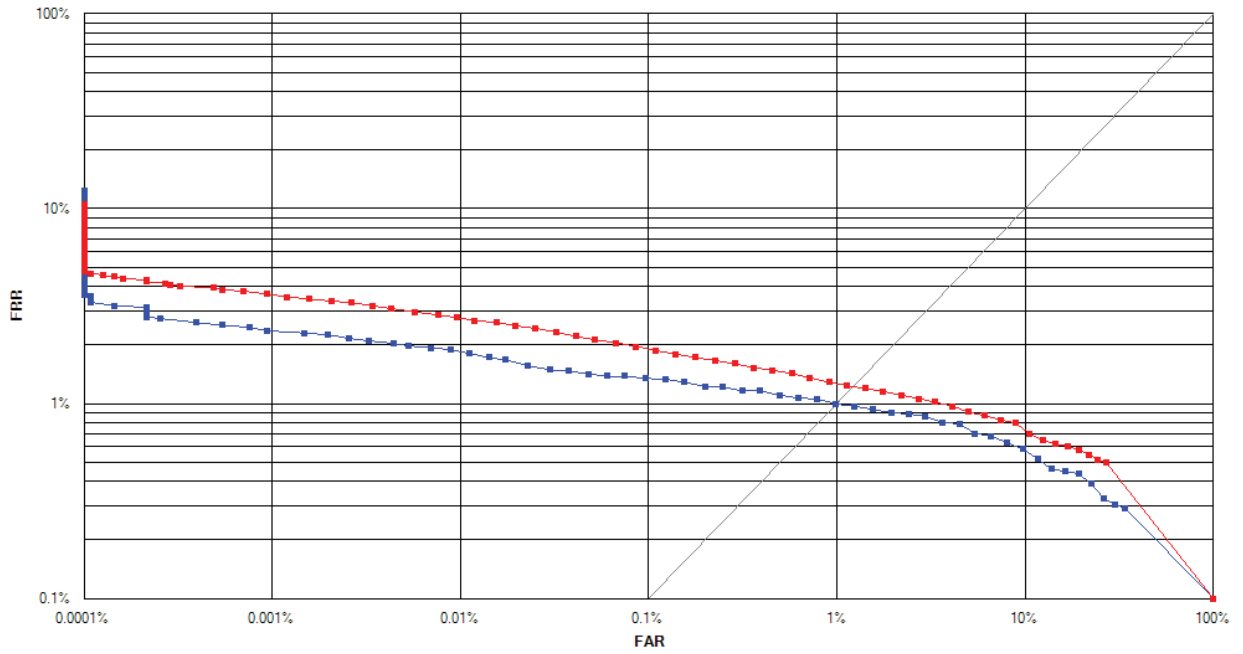
MegaMatcher 4.3 template matching engines reliability testing results				
A template contains these biometric records	FRR at 0.001 % FAR		FRR at 0.0001 % FAR	
	Test 1	Test 2	Test 1	Test 2
1 fingerprint	0.230 %	0.294 %	0.280 %	0.384 %
1 face	2.363 %	3.647 %	3.611 %	4.750 %
1 iris	1.772 %	1.834 %	2.270 %	2.352 %
1 voiceprint	33.820 %		43.930 %	



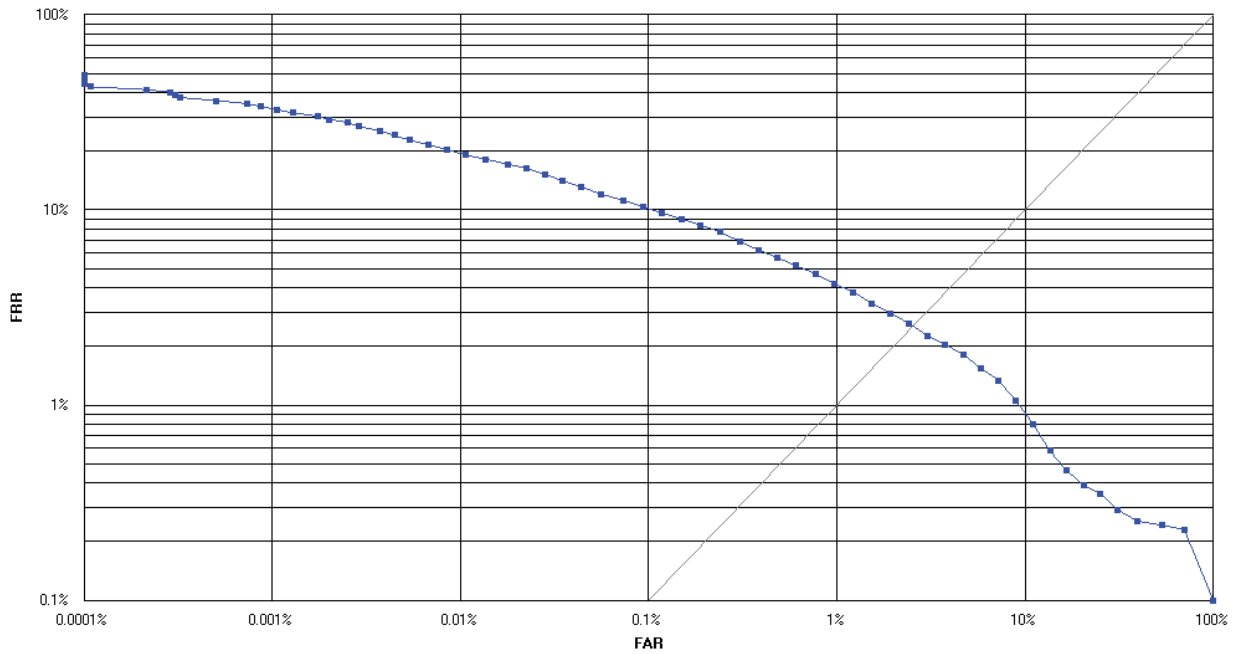
MegaMatcher 4.3 SDK and MegaMatcher Embedded 1.1 SDK fingerprint template matching engine tested on a subset (left index finger only) of SONATEQ Fingerprint Database SQ FDB1-75TS1:
 ■ Maximized matching speed scenario
 ■ Maximized matching accuracy scenario



MegaMatcher 4.3 SDK and MegaMatcher Embedded 1.1 SDK iris template matching engines tested on ND-IRIS-0405 database:
 ■ Maximized matching speed scenario
 ■ Maximized matching accuracy scenario



MegaMatcher 4.3 SDK and MegaMatcher Embedded 1.1 SDK face template matching engines tested on XM2VTS database:
 ■ Maximized matching speed scenario
 ■ Maximized matching accuracy scenario



MegaMatcher 4.3 SDK and MegaMatcher Embedded 1.1 SDK voiceprint template matching engines tested on XM2VTS database.



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 9400** (4 cores), running at **2.67 GHz** clock rate;
- Intel **Core i7-2600** (4 cores), running at **3.4 GHz** clock rate.

MegaMatcher 4.3 single modality matching engines speed testing results (templates per second)				
A template contains these biometric records	Intel Core 2 Q9400		Intel Core i7-2600	
	Test 1	Test 2	Test 1	Test 2
1 fingerprint	61988	108136	124784	220232
1 face	48736	869248	115072	2187344
1 iris	245212	920692	526376	2205376
1 voiceprint	532		912	



Fingerprint, Face and Iris Matching Engines Tests

The identification reliability and speed are important for large-scale systems. MegaMatcher SDK includes a fused algorithm for fast and reliable identification using several biometric templates taken from the same person. The tests with MegaMatcher biometric fingerprint, face and iris matching engines and fused template matching algorithm were performed using Neurotechnology internal multi-biometric database:

- The database had 7,500 sets of biometric records; each set contained 1 face, 2 irises and 10 fingerprints representing a unique person.
- 1,500 unique persons were represented in the database.
- 5 capture sessions were performed for each person.

The tests were performed with these biometric template types:

- **1 fingerprint record** extracted from left index fingerprint image.
- **1 face record.**
- **1 iris record** extracted from left eye image.
- **2 fingerprint records** extracted from same person's left and right index fingerprint images.
- **2 iris records** extracted from same person's different eye images.
- **1 fingerprint + 1 face records** – left index fingerprint and face taken from the same person.
- **1 face + 1 iris records** – left iris and face taken from the same person.
- **1 fingerprint + 1 iris records** – left index fingerprint and left iris taken from the same person.
- **1 fingerprint + 1 face + 1 iris records** – left index fingerprint, left iris and face taken from the same person.

The biometric engines had these parameters set:

- **±90 degrees fingerprint rotation tolerance** value was used for template matching;
- **±15 degrees iris rotation tolerance** value was used for template matching.

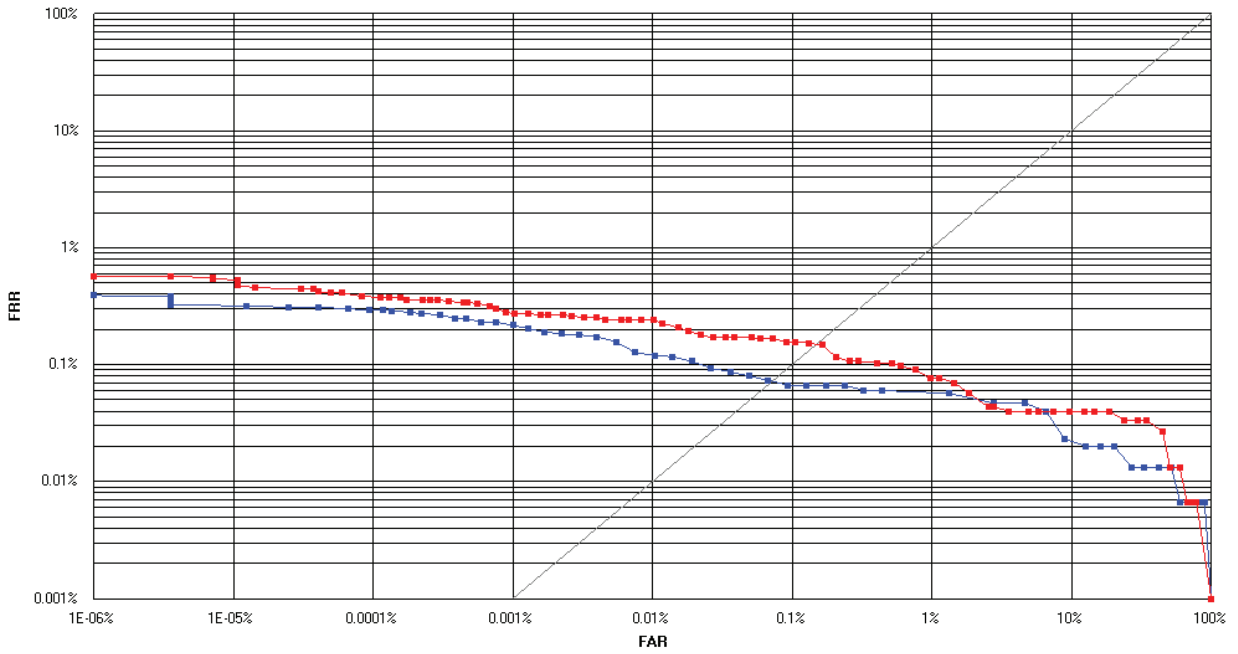
Two tests were performed with each template type:

- **Test 1 maximized matching accuracy.** MegaMatcher 4.3 fused algorithm reliability in this test is shown as **blue curves** on the ROC charts.
- **Test 2 maximized matching speed.** MegaMatcher 4.3 fused algorithm reliability in this test is shown as **red curves** on the ROC charts.

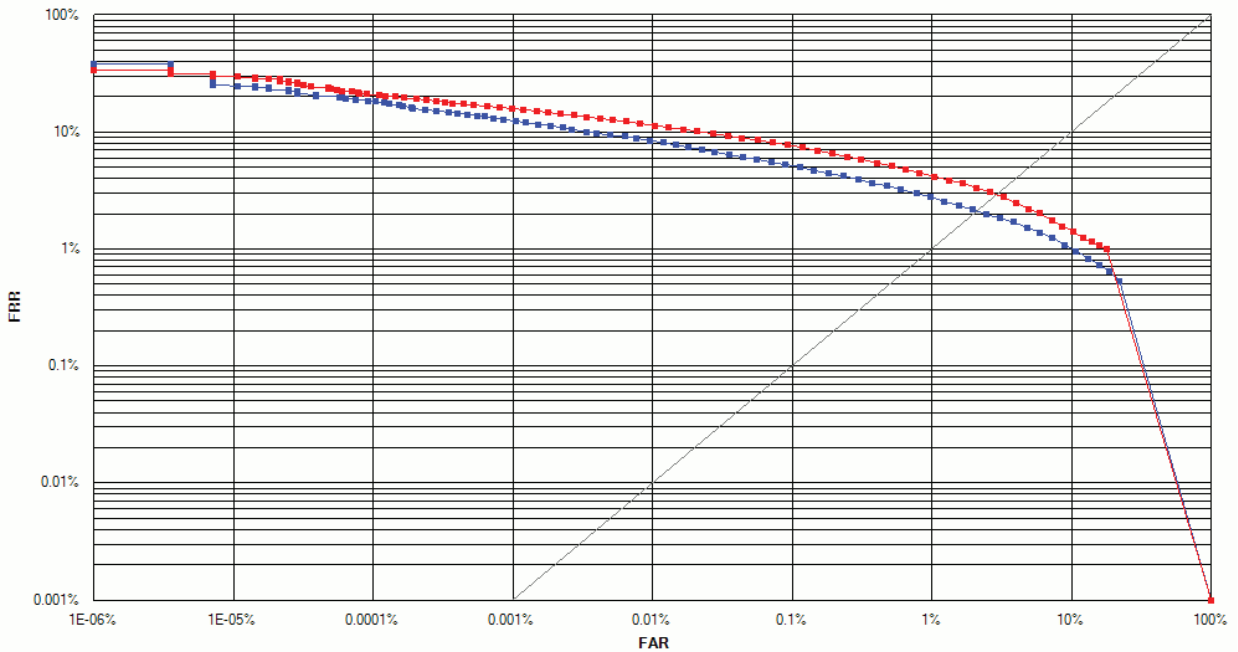
Receiver operation characteristics (**ROC**) curves are usually used to demonstrate the recognition quality of an algorithm. ROC curves show the dependence of false rejection rate (**FRR**) on the false acceptance rate (**FAR**).

MegaMatcher 4.3 template matching engines reliability testing results				
A template contains these biometric records	FRR at 0.001 % FAR		FRR at 0.0001 % FAR	
	Test 1	Test 2	Test 1	Test 2
1 fingerprint	0.230 %	0.280 %	0.294 %	0.384 %
1 face	12.680 %	15.790 %	18.470 %	20.910 %
1 iris	1.167 %	1.253 %	1.467 %	1.547 %
2 fingerprints	0.047 %	0.054 %	0.047 %	0.074 %
2 irises	0.293 %	0.330 %	0.323 %	0.397 %
1 fingerprint + 1 face	0.020 %	0.030 %	0.020 %	0.047 %
1 fingerprint + 1 iris	0.000 %	0.000 %	0.000 %	0.000 %
1 face + 1 iris	0.203 %	0.333 %	0.323 %	0.443 %
1 fingerprint + 1 face + 1 iris ⁽¹⁾	0.000 %	0.000 %	0.000 %	0.000 %

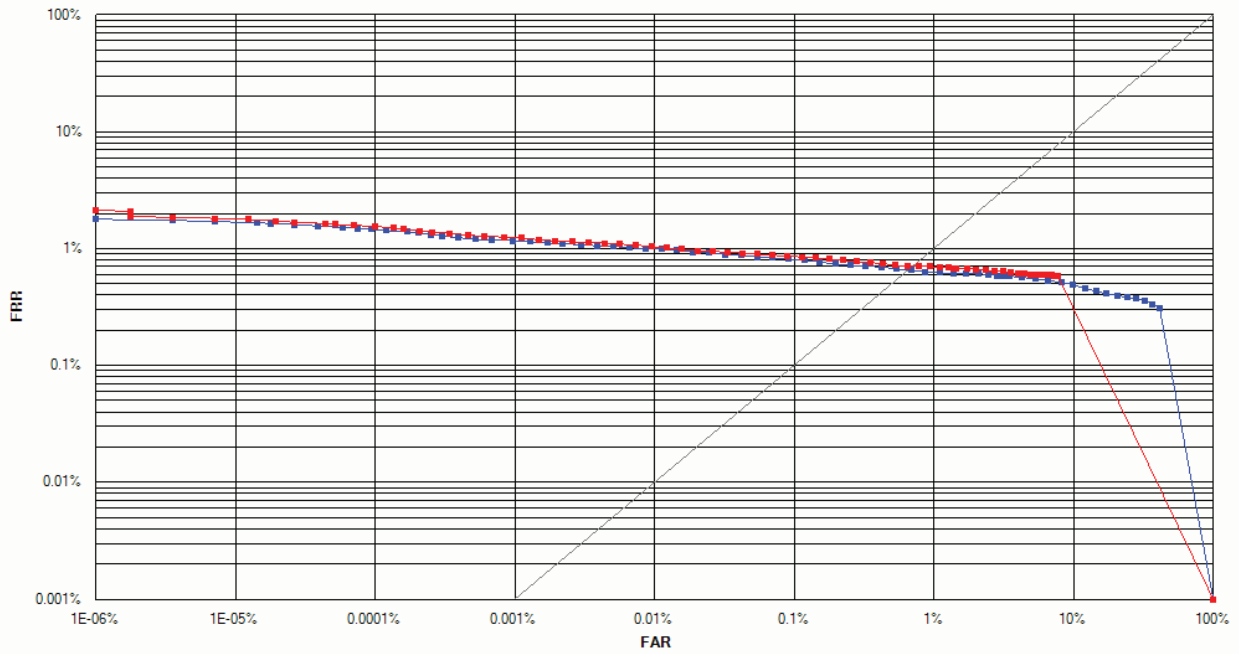
(1) This test produced 0 % FRR for all FAR values, thus the ROC chart is not presented here



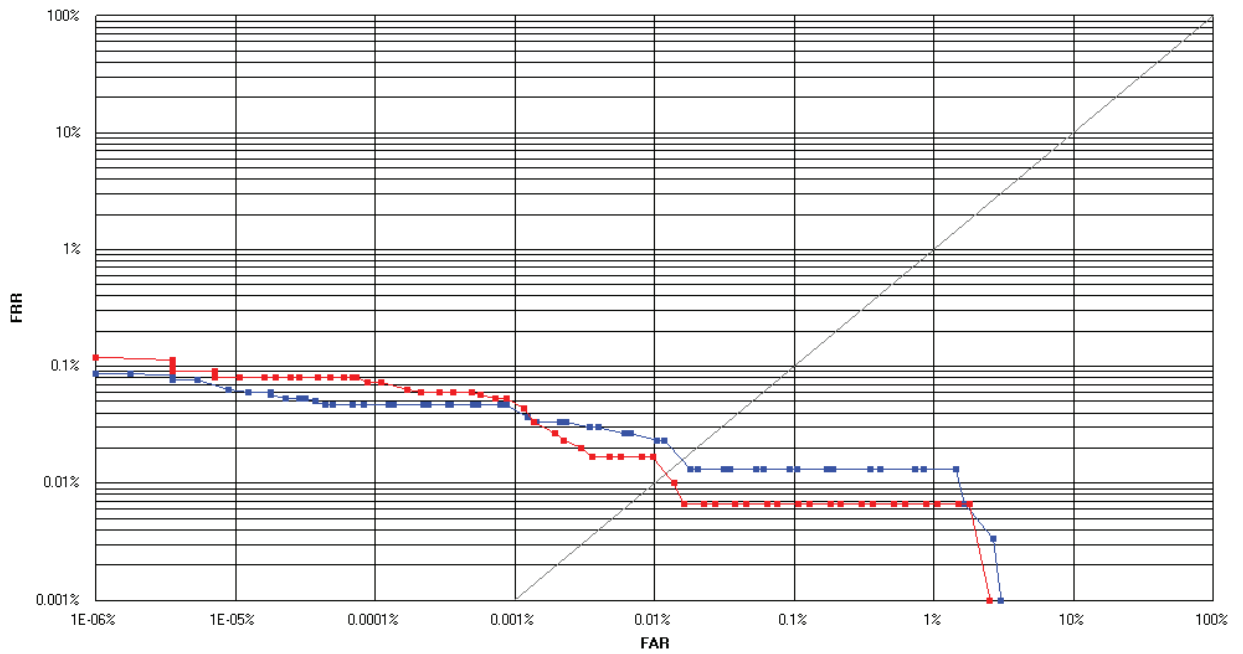
MegaMatcher 4.3 SDK and MegaMatcher Embedded 1.1 SDK fingerprint matching engines;
a template contains 1 fingerprint record:
■ Maximized matching speed scenario
■ Maximized matching accuracy scenario



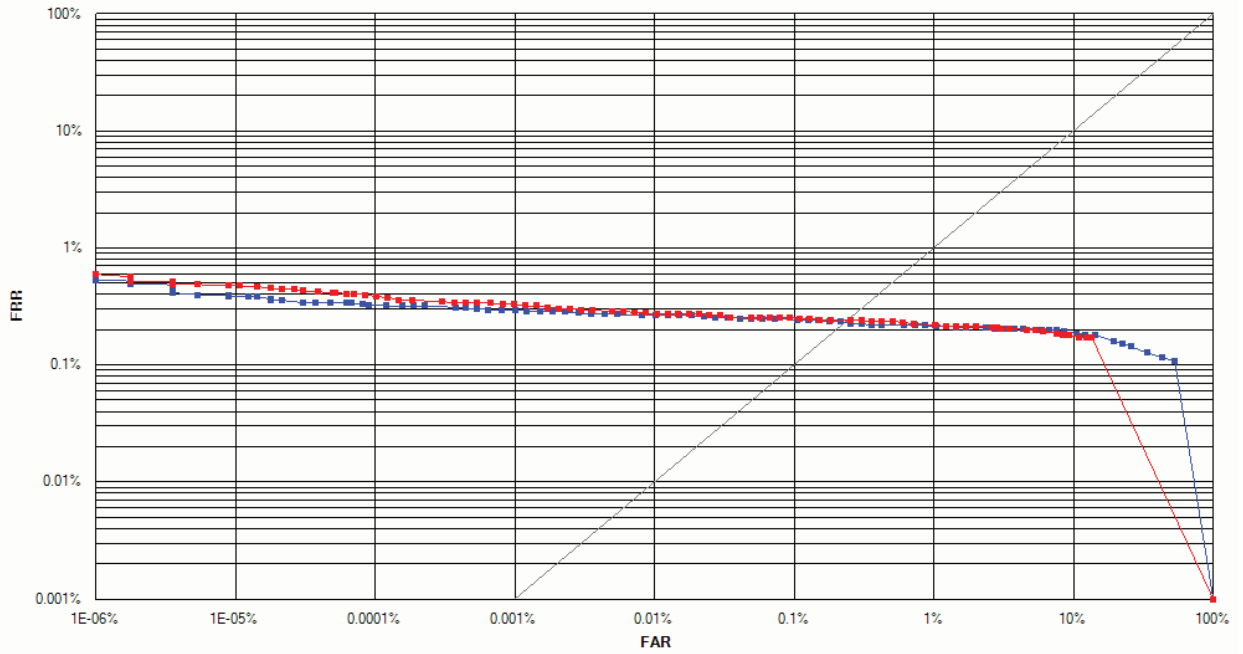
MegaMatcher 4.3 SDK and MegaMatcher Embedded 1.1 SDK face matching engines;
a template contains 1 face record:
■ Maximized matching speed scenario
■ Maximized matching accuracy scenario



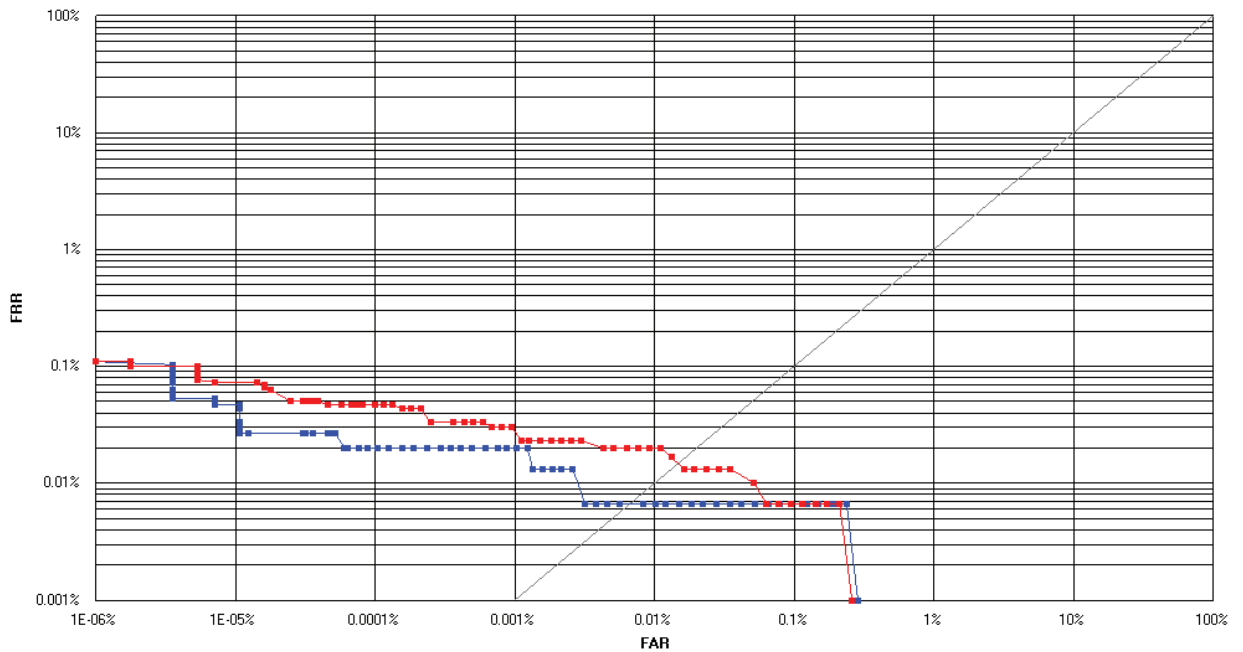
**MegaMatcher 4.3 SDK and MegaMatcher Embedded 1.1 SDK iris matching engines;
a template contains 1 iris record:**
■ Maximized matching speed scenario
■ Maximized matching accuracy scenario



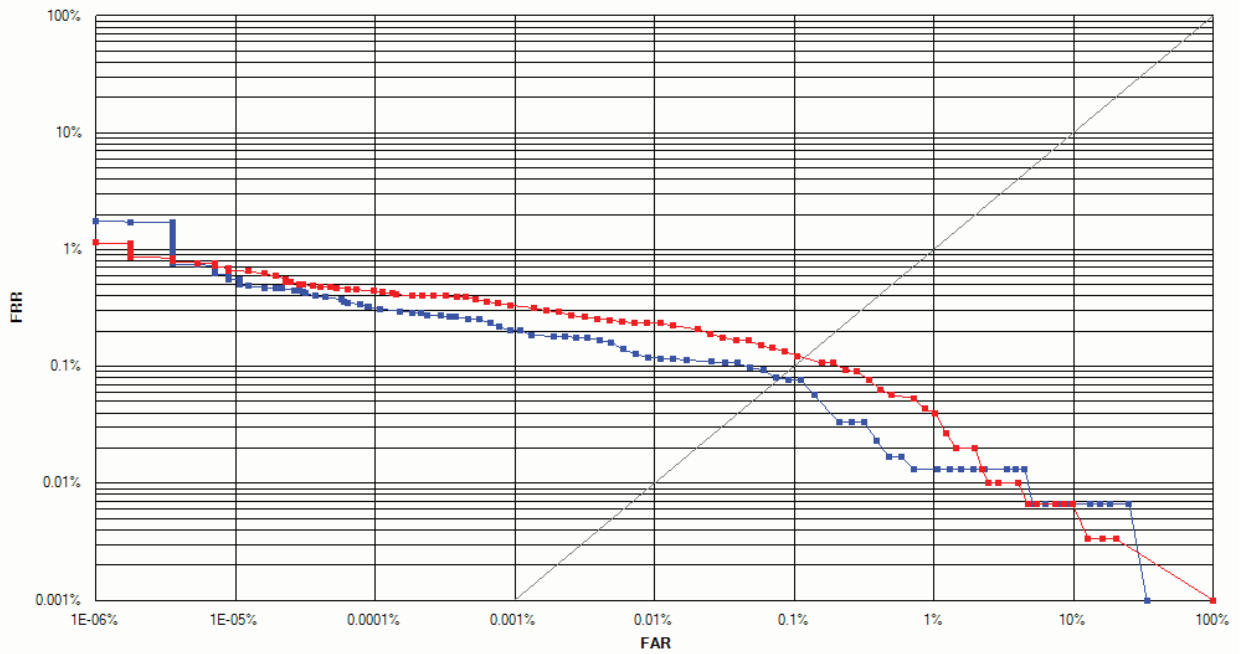
**MegaMatcher 4.3 SDK and MegaMatcher Embedded 1.1 SDK fused template matching engines;
a template contains 2 different fingerprints from the same person:**
■ Maximized matching speed scenario
■ Maximized matching accuracy scenario



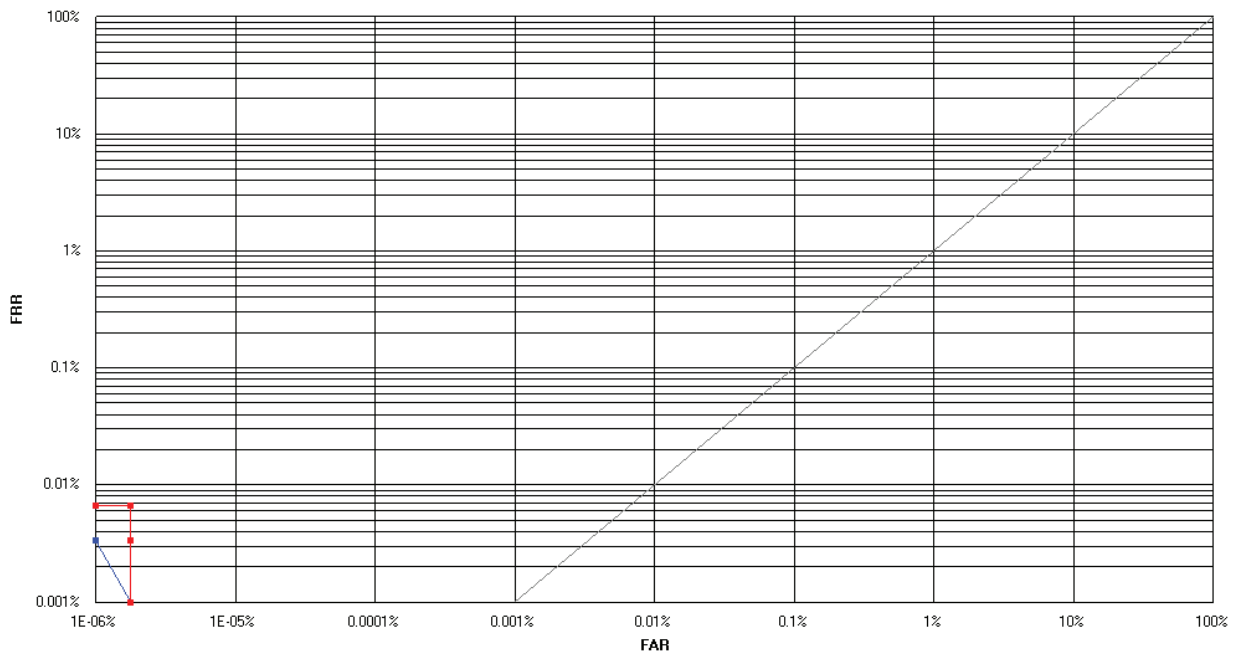
MegaMatcher 4.3 SDK and MegaMatcher Embedded 1.1 SDK fused template matching engines;
 a template contains 2 different irises from the same person:
 ■ Maximized matching speed scenario
 ■ Maximized matching accuracy scenario



MegaMatcher 4.3 SDK and MegaMatcher Embedded 1.1 SDK fused template matching engines;
 a template contains 1 fingerprint and 1 face from the same person:
 ■ Maximized matching speed scenario
 ■ Maximized matching accuracy scenario



**MegaMatcher 4.3 SDK and MegaMatcher Embedded 1.1 SDK fused template matching engines;
a template contains 1 face and 1 iris from the same person:**
■ Maximized matching speed scenario
■ Maximized matching accuracy scenario



**MegaMatcher 4.3 SDK and MegaMatcher Embedded 1.1 SDK fused template matching engines;
a template contains 1 fingerprint and 1 iris from the same person:**
■ Maximized matching speed scenario
■ Maximized matching accuracy scenario



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 9400 (4 cores), running at 2.67 GHz clock rate;
- Intel Core i7-2600 (4 cores), running at 3.4 GHz clock rate.

MegaMatcher 4.3 matching engines speed testing results (templates per second)				
A template contains these biometric records	Intel Core 2 Q9400		Intel Core i7-2600	
	Test 1	Test 2	Test 1	Test 2
1 fingerprint	61998	108136	124784	220232
1 face	62560	1037720	133504	2441736
1 iris	253476	1032628	542840	2424296
2 fingerprints	30452	54176	60992	109528
2 irises	131568	592160	279288	1437592
1 fingerprint + 1 face	29784	97760	63856	201096
1 fingerprint + 1 iris	49300	97820	100792	201336
1 face + 1 iris	49924	554180	106992	1334264
1 fingerprint + 1 face + 1 iris	26508	89300	56824	184136

These tests show that a large-scale automated biometric identification system based on MegaMatcher provides high identification reliability when using fingerprints, using fused same-biometric (different fingerprints or irises from the same person) matching significantly reduces FRR, and using multi-biometric identification results in a significant reliability increase, allowing the system to reach almost 0 % FRR.



Voiceprint and Face Matching Engine Tests

The tests with MegaMatcher biometric face and voiceprint matching engines, and the fused template matching algorithm were performed using face images and voice samples from the XM2VTS Database:

- 295 unique persons were represented in the database.
- 8 capture sessions were performed for each person.
- The *phrase 1* from the database was used for the testing, meaning that the same **fixed phrase** was used for all subjects.

The tests were performed with these biometric template types:

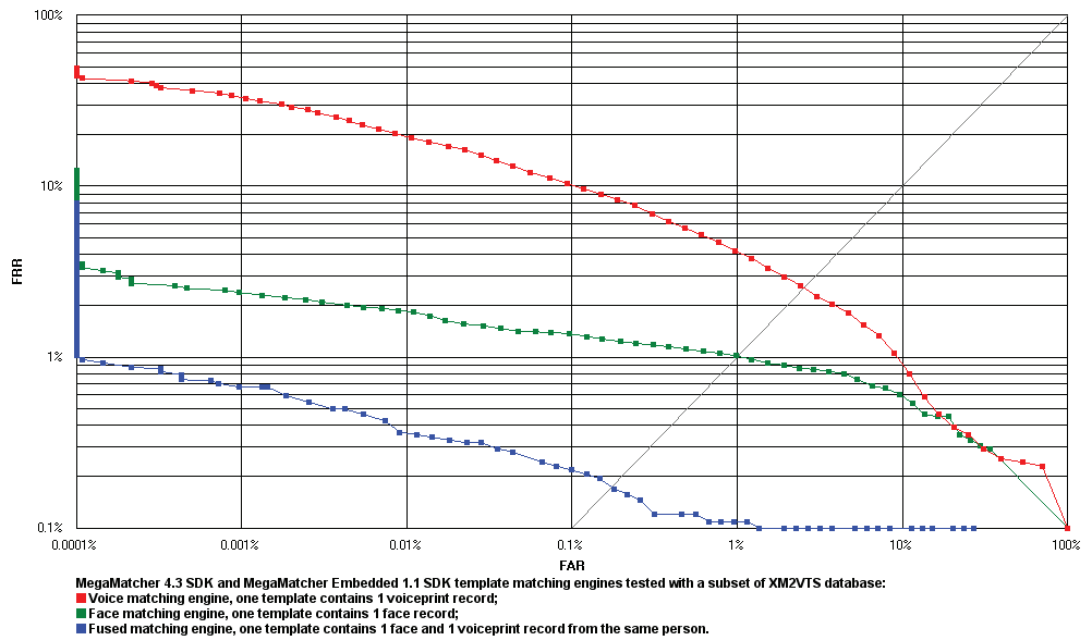
- 1 voiceprint record.
- 1 face record.
- 1 voiceprint + 1 face records taken from the same person.

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 9400** (4 cores), running at **2.67 GHz** clock rate;
- Intel **Core i7-2600** (4 cores), running at **3.4 GHz** clock rate.

MegaMatcher 4.3 face, voiceprint and fused template matching engines tests				
A template contains these biometric records	Matching speed (templates per second)		FRR at 0.001 % FAR	FRR at 0.0001 % FAR
	Intel Core 2 Q9400	Intel Core i7-2600		
1 voiceprint	532	912	33.820 %	43.930 %
1 face	48736	115072	2.387 %	3.574 %
1 voiceprint + 1 face	524	912	0.666 %	1.017 %

Receiver operation characteristics (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).

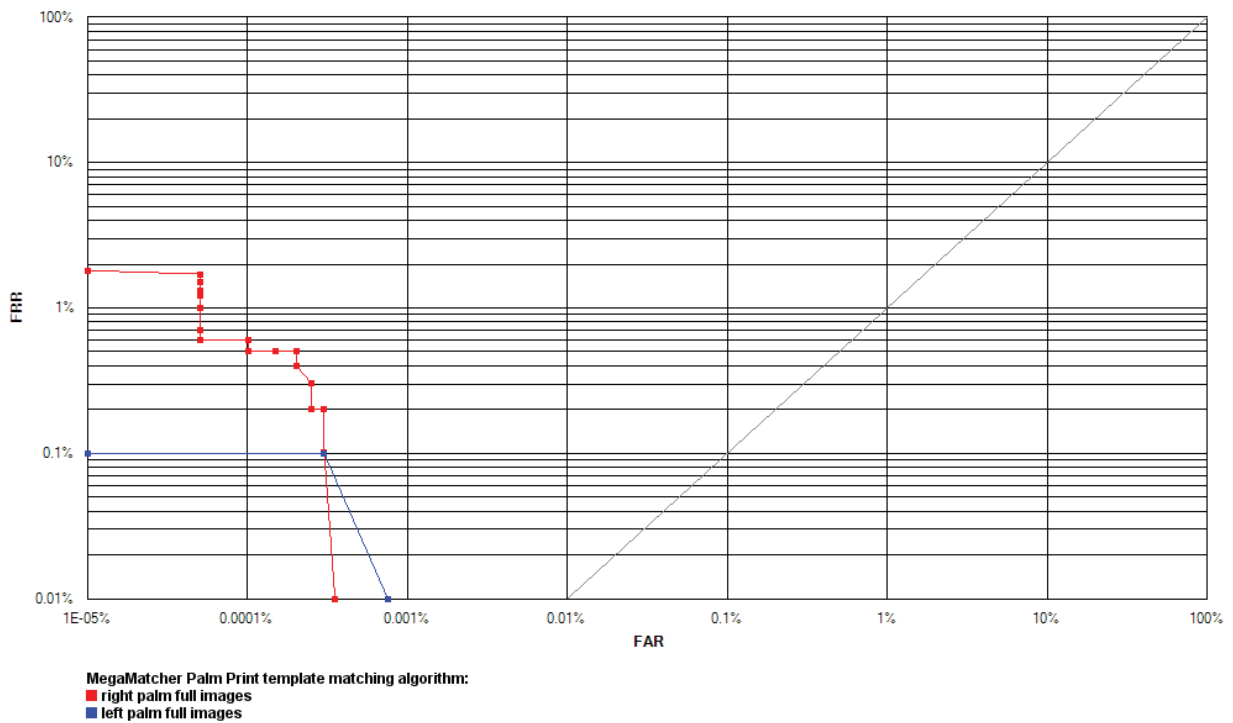




Palm Print Engine Tests

The MegaMatcher Palm Print template matching algorithm reliability tests were performed using internal palm print images database. The database contained 1,993 images of right hand full palms and 1,996 images of left hand full palms. The database represented 1,000 unique persons.

Receiver operation characteristics (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). The chart with ROC curves for the MegaMatcher Palm Print template matching algorithm are available below.





MegaMatcher SDK Trial, Demo Applications and Related Products

MegaMatcher **30-day SDK Trial**, as well as fingerprint, face and iris engines **demo applications** are available for downloading at www.neurotechnology.com/download.html

These products are related to MegaMatcher SDK:

- **MegaMatcher Accelerator 4.0** – a solution for building the server-side of a large-scale AFIS or multi-biometric system; available in Standard and Extended versions; a single MegaMatcher Accelerator Standard matches **35 million fingerprints per second** or **50 million irises per second**, and the Extended matches **100 million fingerprints per second** or **200 million irises per second**. See “MegaMatcher Accelerator” brochure for more information.
- **MegaMatcher Embedded SDK** – a product for multi-biometric fingerprint, face, speaker and iris recognition on Android smartphones, tablets and other mobile devices. Produces biometric **templates** that are the **same** as in MegaMatcher SDK, thus can be also used for developing biometric client-side mobile applications for systems with server-side based on MegaMatcher SDK. See “MegaMatcher Embedded 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.
- **VeriFinger SDK** – intended for development of PC-based or Web-based fingerprint identification systems. See “VeriFinger SDK” brochure for more information.
- **VeriLook SDK** – intended for development of PC-based or Web-based face identification systems. See “VeriLook SDK” brochure for more information.
- **VeriEye SDK** – intended for development of PC-based or Web-based iris identification systems. See “VeriEye SDK” brochure for more information.
- **VeriSpeak SDK** – intended for development of PC-based or Web-based speaker recognition applications. See “VeriSpeak SDK” brochure for more information.



Licensing MegaMatcher SDK

The following licensing model is intended for **end-user** product developers. Integrators who want to develop and sell a MegaMatcher-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 MegaMatcher 4.3 Standard SDK (EUR 2,590) or MegaMatcher 4.3 Extended SDK (EUR 4,990) to develop a product based on MegaMatcher technology. The SDK needs to be purchased just once and may be used by all the developers within the integrator's company.

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

MegaMatcher SDK components and licenses		
Component types	MegaMatcher 4.3 Standard SDK	MegaMatcher 4.3 Extended SDK
Fingerprint component licenses included with a specific SDK:		
• Fingerprint Matcher	1 single computer license	1 single computer license
• Fast Fingerprint Matcher	1 single computer license	2 single computer licenses
• Fingerprint Client ⁽¹⁾	3 single computer licenses and 1 concurrent license	3 single computer licenses and 1 concurrent license
• Fingerprint Extractor	1 single computer license	1 single computer license
Face component licenses included with a specific SDK:		
• Face Matcher	1 single computer license	1 single computer license
• Fast Face Matcher	1 single computer license	2 single computer licenses
• Face Client ⁽²⁾	3 single computer licenses and 1 concurrent license	3 single computer licenses and 1 concurrent license
• Face Extractor	1 single computer license	1 single computer license
Voice component licenses included with a specific SDK:		
• Voice Matcher	1 single computer license	1 single computer license
• Voice Client	3 single computer licenses and 1 concurrent license	3 single computer licenses and 1 concurrent license
• Voice Extractor	1 single computer license	1 single computer license
Iris component licenses included with a specific SDK:		
• Iris Matcher	1 single computer license	1 single computer license
• Fast Iris Matcher	1 single computer license	2 single computer licenses
• Iris Client ⁽³⁾	3 single computer licenses and 1 concurrent license	3 single computer licenses and 1 concurrent license
• Iris Extractor	1 single computer license	1 single computer license
Palm print component licenses included with a specific SDK:		
• Palm Print Matcher	1 single computer license	2 single computer licenses
• Palm Print Client	1 single computer license	1 single computer license
Server and cluster component licenses included with a specific SDK:		
• Matching Server	+	+
• Cluster Server		1 single computer license

Notes:

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

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

(3) Iris Client component includes Iris Extractor and Iris 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 on this page.

Additional component licenses may be obtained by MegaMatcher 4.3 SDK customers as required by their development process.

Product Deployment

To deploy a product developed with MegaMatcher 4.x SDK, an integrator need obtain only the additional licenses required for the particular MegaMatcher 4.3 components that will run on each CPU of their customers computers. The available MegaMatcher components and license types for product deployment are the same as for product development.

Each MegaMatcher 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 MegaMatcher 4.3 SDK and additional MegaMatcher component licenses can be found in the next chapter.

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 MegaMatcher 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 MegaMatcher component to run. The available activation options are listed below.

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

Concurrent network licenses

Concurrent licenses are available for Fingerprint Client, Face Client, Voice Client or Iris Client components, allowing the installation of these specific components 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, voice or iris capturing/enrolling and 0.1-0.2 second for fingerprint enrolling. After this interval the license is released, making it available for another user. One Fingerprint Client, Face Client, Voice Client or Iris Client concurrent license can be shared among tens or hundreds of users, making these licenses especially **useful for web-based** software.

The number of simultaneously running Fingerprint Client, Face Client, Voice Client and Iris 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 MegaMatcher 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 MegaMatcher 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 MegaMatcher 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 MegaMatcher 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 MegaMatcher 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 MegaMatcher component may be used as a dongle, allowing the MegaMatcher component to run on the particular computer where the dongle is attached.

MegaMatcher enterprise license

The MegaMatcher enterprise license allows an **unlimited use** of MegaMatcher 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. MegaMatcher enterprise licenses are intended for larger projects, with pricing starting at **EUR 80,000**.

For more information please contact us.



Prices for MegaMatcher 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.

MegaMatcher SDK

MegaMatcher 4.3 Standard SDK	€ 2,590.00
MegaMatcher 4.3 Extended SDK	€ 4,990.00

Fingerprint, Face, Voice and Iris Client components concurrent licenses

	Fingerprint Client	Face Client	Voice Client	Iris Client
Price per license	€ 590.00	€ 390.00	€ 390.00	€ 1,200.00

Fingerprint components (prices per single computer license)

Quantity	Fingerprint Client	Fingerprint Matcher	Fast Fingerprint Matcher
1-9	€ 35.00	€ 25.00	€ 540.00
10-19	€ 26.00	€ 18.00	€ 390.00
20-49	€ 23.00	€ 16.00	€ 355.00
50-99	€ 20.00	€ 14.00	€ 305.00
100-199	€ 18.00	€ 12.50	€ 275.00
200-499	€ 16.00	€ 11.00	€ 245.00
500-999	€ 14.00	€ 10.00	€ 215.00
1000-1999	€ 12.00	€ 9.00	€ 190.00
2000-3999	€ 11.00	€ 8.00	€ 170.00
4000-7999	€ 10.00	€ 7.00	€ 155.00
8000 and more	Please contact us for more information		

Face components (prices per single computer license)

Quantity	Face Client	Face Matcher	Fast Face Matcher
1-9	€ 25.00	€ 25.00	€ 160.00
10-19	€ 18.00	€ 18.00	€ 120.00
20-49	€ 16.00	€ 16.00	€ 105.00
50-99	€ 14.00	€ 14.00	€ 90.00
100-199	€ 12.50	€ 12.50	€ 80.00
200-499	€ 11.00	€ 11.00	€ 70.00
500-999	€ 10.00	€ 10.00	€ 63.00
1000-1999	€ 9.00	€ 9.00	€ 57.00
2000-3999	€ 8.00	€ 8.00	€ 51.00
4000-7999	€ 7.00	€ 7.00	€ 45.00
8000 and more	Please contact us for more information		



Voice components (prices per single computer license)

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

Iris components (prices per single computer license)

Quantity	Iris Client	Iris Matcher	Fast Iris Matcher
1-9	€ 101.00	€ 124.00	€ 800.00
10-19	€ 74.00	€ 90.00	€ 580.00
20-49	€ 65.00	€ 80.00	€ 520.00
50-99	€ 57.00	€ 70.00	€ 450.00
100-199	€ 51.00	€ 63.00	€ 405.00
200-499	€ 46.00	€ 56.00	€ 360.00
500-999	€ 41.00	€ 49.00	€ 315.00
1000-1999	€ 36.00	€ 44.00	€ 280.00
2000-3999	€ 32.00	€ 40.00	€ 255.00
4000-7999	€ 29.00	€ 36.00	€ 230.00
8000 and more	Please contact us for more information		

Cluster server component (prices per single computer license)

Quantity	Price
1-9	€ 1,790.00
10-19	€ 1,290.00
20 and more	Please contact us for more information

Palm print components (prices per single computer license)

Quantity	Palm Print Client	Palm Print Matcher
1-9	€ 123.00	€ 154.00
10-19	€ 90.00	€ 112.00
20-49	€ 80.00	€ 100.00
50-99	€ 70.00	€ 87.00
100 and more	Please contact us for more information	

License management

Volume License Manager dongle	€ 16.00
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MegaMatcher 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