Iris Exchange (IREX) 10: Ongoing Evaluation of Iris Recognition Identification Track

Concept, Evaluation Plan, and API Specification
Version 0.1b

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Questions and Comments to irex@nist.gov

The latest version of this document is available at: https://www.nist.gov/itl/iad/image-group/ongoing-irex

July 25, 2019
Release Notes

The latest version of this document can be downloaded from https://www.nist.gov/itl/iad/image-group/ongoing-irex.

Inquiries and comments may be submitted to irex@nist.gov. Subscribe to the IREX mailing list by sending an email to irex+subscribe@list.nist.gov.

The submission procedure, implementation, and runtime requirements for IREX 10 are similar to those of prior IREX evaluations. However, the API has undergone significant changes.

Timeline

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 26th, 2019</td>
<td>CONOPS &amp; API document open for comment.</td>
</tr>
<tr>
<td>Sep 7th, 2019</td>
<td>CONOPS &amp; API document frozen.</td>
</tr>
<tr>
<td>Sep 30th, 2019 onwards</td>
<td>NIST accepting submissions.</td>
</tr>
</tbody>
</table>
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1 Overview

1.1 Introduction

This document establishes a concept of operations (CONOPS) and application programming interface (API) specification for the Iris Exchange (IREX) 10 Ongoing Evaluation of Iris Recognition, Identification Track. Administered offline at NIST’s Biometrics Research Lab (BRL), developers submit their matching software for testing over sequestered iris data. As an ongoing evaluation, developers may submit at any time (unless otherwise specified on the IREX 10 website).

The Identification Track of IREX 10 assesses performance for one-to-many (aka identification mode) applications. Most flagship deployments of iris recognition operate in one-to-many mode, providing services ranging from prison management, border security, expedited processing, distribution of resources, and database de-duplication.

IREX 10 is the latest installment of the IREX umbrella program. IREX was initiated by NIST to support the standardization, development, and deployment of iris-based technology. Although IREX 10 is the first ongoing IREX evaluation, it does not preclude the possibility that NIST will conduct future one-off evaluations as part of IREX. The latest information on IREX can be found on the IREX website.

1.2 Publication of Results

NIST will post performance results for each submitted implementation to the IREX 10 website, in periodic NIST interagency reports, and possibly other places as well.

1.3 Performance Metrics

Performance is assessed for one-to-many matching. One-to-many systems are tasked with searching individuals against an enrolled population and returning the searched individual’s correct identity if found. The identification step involves producing a list of candidate identities, each with a comparison score quantifying the degree of similarity (or dissimilarity) of the candidate to the searched individual.

Offline software tests such as IREX 10 cannot mimic all aspects of a deployed system. Nevertheless, general performance metrics can provide insight into the capabilities and potential of specific biometric technologies. Below is a list of performance factors that may be assessed in IREX 10:

**Matching Accuracy** Accuracy will be presented in the form of Detection Error Trade-off (DET) plots [1]. These plots present matching accuracy as a trade-off between two error rates as a decision threshold is adjusted. Examples of DET plots can be found in the first IREX IX report. Other accuracy statistics that may be report are the false negative identification rate (FNIR) at a fixed false positive identification rate (FPIR) and purely rank-based statistics such as rank R “hit” and “miss” rates.

IREX 10 is conducted entirely offline without any real-time image acquisition component. As such, it is not possible to prompt for a new sample if the given sample is deemed to be of insufficient quality. Failures to extract useful feature information from iris images will effectively inflate the “miss rate” in accuracy statistics.

**Computation Time** Timing will be assessed as the elapsed real time (as opposed to CPU time) for core biometric operations (e.g. feature extraction, identification). Timing estimates will be computed on an unloaded machine running a single process. The machine’s specifications are described in Section 3.1. NIST may also explore the relationship between search time and the size of the enrollment database, with an eye on whether the relationship is sub-linear.

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1IREX 10 Hompage: https://www.nist.gov/itl/iad/image-group/ongoing-irex
2IREX Homepage: http://www.nist.gov/itl/iad/ig/irex.cfm
Overview

**Accuracy-speed Trade-off**  NIST may investigate whether a collective accuracy-speed trade-off exists for submitted implementations. Accuracy-speed trade-off refers to the phenomenon where more accurate implementations take longer to complete their operations.

**Template Sizes**  NIST will report the size of the proprietary matching templates generated by the implementation.

**Runtime Memory Usage**  NIST may monitor runtime memory usage during identification and/or feature extraction.
2 Participation Requirements

2.1 Who Can Participate

Participation is open to any commercial organization or academic institution that has the ability to implement an iris matching algorithm. There is no charge and participation is open worldwide.

A high-level description of the process is as follows:

1. Mail the completed Participation Agreement\(^5\) to NIST.
2. Wrap your matching software in a C++ software library that adheres to the API specifications and runtime requirements described in Section 4 of this document.
3. Submit your implementation to NIST, following the cryptographic protection procedures described in Section 2.3.
4. NIST will validate your submission to ensure its correct operation (Section 2.4).
5. NIST will assess the performance of your implementation and post the results to the IREX 10 webpage.

Participants only need to complete the Participation Agreement the first time they submit an implementation. Participants are permitted to submit a new implementation every 3 months.

2.2 Implementation Requirements

2.2.1 Linking

Participants shall submit their implementations as pre-compiled and linkable libraries. Both shared and static libraries are permitted. The library name shall be libIREX10.so if shared and libIREX10.a if static. Additional dynamic or shared library files may be submitted that support this core library. Participants shall not provide any source code. Header files should not be necessary, but if provided, should not contain any intellectual property or any material that is otherwise proprietary.

NIST will link the submitted library file(s) to our ISO 2011 C++ language test drivers. Participants are required to provide their libraries in a format that is linkable using g++ version 4.8.5. Thus, libraries must export their functions according to that compiler's naming convention. The functions that must be exported are defined in "irex.h" (found in the validation package) and described in Section 4 of this document. The software libraries must be 64-bit. Participants may provide customized command-line linking parameters. A typical link line might be:

```
g++ -I. -Wall -m64 -o irex_main irex_main.cpp -L. -lIREX10
```

Participants are strongly advised to verify library-level compatibility with g++ (on an equivalent platform) prior to submitting their software to NIST to avoid linkage problems (e.g. symbol name and calling convention mismatches, incorrect binary file formats, etc.). NIST’s test machines will have CentOS 7.6 installed, which can be downloaded from nigos.nist.gov (https://nigos.nist.gov/evaluations/CentOS-7-x86_64-Everything-1810.iso).

Intel ICC is not available. Access to GPUs is not permitted. Intel Integrated Performance Primitives (IPP) libraries are permitted if they are delivered as part of the developer-supplied library package. It is the provider's responsibility to establish proper licensing of all libraries.

NIST will ignore requests to alter parameters by hand (e.g. modify specific lines in an XML configuration file). Any such adjustments must be submitted as new implementations.

\(^5\)The participation agreement can be found on page 15 of this document
Participation Requirements

Dependencies on external dynamic/shared libraries such as compiler-specific development environment libraries are discouraged. If absolutely necessary, external libraries must be provided to NIST after receiving prior approval from the test liaison. Image processing libraries such as libpng and NetPbm should not be required since NIST will handle image reading and decompression.

2.2.2 Installation

Installation Must be Simple Installation shall require the simple copying and/or decompression of files followed by a linking operation. There shall be no need for interaction with the participant provided everything goes smoothly. It shall not require an installation program.

No License Requirements or Usage Restrictions The implementation shall allow itself to be executed on any number of machines without the need for machine-specific license control procedures or activation. The implementation shall neither implement nor enforce any usage controls or restrictions based on licenses, number of executions, presence of temporary files, etc. No activation dongles or other hardware shall be required.

Sufficient Documentation Must be Provided Documentation should be provided for all (non-zero) participant-defined error or warning return codes.

Disk-Space Limitations The implementation may use configuration files and supporting data files. The total size of all libraries and configuration and data files for any given submission shall not be more than a gigabyte.

2.2.3 Runtime

Single-threaded Requirement Implementations must run in single-threaded mode.

No writing to Standard Error or Standard Output The implementation will be tested in a non-interactive “batch” mode without terminal support. Thus, the submitted library shall run quietly (i.e. it should not write messages to “standard error” or “standard output”. An implementation may write debugging messages to a log file. This log file must be declared in the documentation.

Exception Handling Should be Supported The implementation should support error/exception handling so that, in the case of an unexpected error, a return code is still provided to the calling application. The NIST test harness will gracefully terminate itself if it receives an unexpected return code, as it usually indicates improper operation of the implementation.

No External Communication Implementations running on NIST hosts shall not side-effect the runtime environment in any manner except through the allocation and release of memory. Implementations shall not write any data to an external resource (e.g. a server, connection, or other process). Implementations shall not attempt to read any resource other than those explicitly allowed in this document. If detected, NIST reserves the right to cease evaluation of the software, notify the participant, and document the activity in published reports.

Components Must be Stateless All implementation components shall be “stateless” except as noted elsewhere in this document. This applies to iris detection, feature extraction and matching. Thus, all functions should give identical output, for a given input, independent of the runtime history. NIST will institute appropriate tests to detect stateful behavior. If detected, NIST reserves the right to cease evaluation of the software, notify the participant, and document the activity in published reports.

Minimum Speed Requirements The implementations shall perform operations within the time constraints specified by Table 1. These time limits apply to the function call invocations defined in Section 4 on a Dell M910 system described in Section 3.1. Since NIST cannot regulate the maximum runtime per operation, limitations are specified as 90th percentiles (i.e. 90% of all calls to the function shall complete in less time than the specified duration). The limitations assume each template is generated from a single iris image.
**Table 1: Time limitations for specific operations.**

<table>
<thead>
<tr>
<th>Operation</th>
<th>Timing Restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creation of a verification template from a single 640x480 pixel image</td>
<td>1000 ms</td>
</tr>
<tr>
<td>Creation of an enrollment template from a single 640x480 pixel image</td>
<td>1000 ms</td>
</tr>
<tr>
<td>Search duration on a database of one million templates</td>
<td>20,000 ms</td>
</tr>
</tbody>
</table>

**Template Size**  Templates should not require more than 100 KB of persistent storage per iris image. Participants should inform NIST if their implementations require more than 100 KB of persistent storage.

### 2.3 Submission Procedure

All software, data, and configuration files submitted to NIST must be signed and encrypted. Signing is performed to ensure authenticity of the submission (i.e., that it actually belongs to the participant). Encryption is performed to ensure privacy. Implementations shall be submitted to NIST as encrypted gpg files. Encryption shall follow the procedures described at [http://www.nist.gov/itl/ig/encrypt.cfm](http://www.nist.gov/itl/ig/encrypt.cfm).

If the encrypted implementation is below 20MB, it can be emailed directly to the IREX 10 Liaison (irex@nist.gov). If the encrypted implementation is above 20MB, it can be provided to NIST as a download from a webserver. NIST shall not be required to register or enroll in any kind of membership before downloading the implementation. Providing NIST with a Google Drive link is recommended. For security reasons, Dropbox links are not currently accepted.

**NOTE:** NIST will not accept any implementations that are not signed and encrypted. NIST accepts no responsibility for anything that occurs as a result of receiving files that are not encrypted with the NIST public key.

All submissions shall adhere to the naming convention described in Table 2.

**Table 2: Naming convention for a submitted implementation.**

<table>
<thead>
<tr>
<th>Name Format:</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>irex10_1N</td>
<td>Fixed for all submissions.</td>
</tr>
<tr>
<td>&lt;participantName&gt;</td>
<td>A short name for the participant (e.g. &quot;thebes&quot;).</td>
</tr>
<tr>
<td>&lt;increment&gt;.&lt;ext&gt;.gpg</td>
<td>A two-digit zero-indexed identifier that increments anytime a new submission is provided to NIST.</td>
</tr>
<tr>
<td>compression type (e.g. &quot;zip&quot;, &quot;tar&quot;)</td>
<td></td>
</tr>
</tbody>
</table>

**Example:**  irex10_1N_thebes_00.tar.gz.gpg

### 2.4 Software Validation

Upon receipt, NIST will validate the implementation to ensure its correct operation. The validation process involves running the implementation over a small sample of test data. This test data will be provided to the participant, who must run the implementation in-house and provide NIST with the comparison results. NIST will then verify that the participant’s in-house results are consistent with the output produced in the NIST BRL. The validation data along with instructions can be downloaded from the IREX 10 webpage ([https://www.nist.gov/itl/ig/ongoing-irex](https://www.nist.gov/itl/ig/ongoing-irex)).
3 Test Environment

3.1 Hardware

Testing is performed offline at a NIST facility on a secure “air-gapped” network. Hardware specifications for some of the test machines in NIST’s Biometrics Research Laboratory (BRL) are:

- Dell M610 - Dual Intel Xeon X5680 3.3 GHz CPUs (6 cores each).
- Dell M910 - Dual Intel Xeon X7560 2.3 GHz CPUs (8 cores each).
- Dual Intel Xeon E5-2695 3.3 GHz CPUs (14 cores each; 56 logical CPUs total).

The test machines have CentOS 7.6 installed. An ISO image of the distribution can be downloaded from nigos.nist.gov (https://nigos.nist.gov/evaluations/CentOS-7-x86_64-Everything-1810.iso).

3.2 Iris Datasets

Currently, IREX 10 only tests over a single iris dataset, but this is likely to change as additional datasets become available. The current test datasets are:

- **Operational Dataset (OPS) IV**: OPS IV is comprised of field collected iris images. The images are pulled from the same source as OPS III (used for performance testing in IREX IX). The images were collected from various locations over a period of years. Field collected iris images tend to suffer more from quality related problems (e.g. motion blur) than those collected in more controlled laboratory settings.

All test datasets are sequestered (i.e. not publicly accessible). The participants are not allowed to view any of the iris samples and will not be provided with a representative set of iris samples.

**Ground Truth Integrity**: A hazard with collecting operational data is that ground truth identity labels can be incorrectly assigned due to clerical error. NIST will attempt to correct ground truth errors in its test datasets whenever possible, and only when doing so will not unfairly bias results in favor of specific implementations.

4 API Specification

The design of this API reflects the following testing objectives:

- Support black-box testing.
- Support distributed processing.
- Support graceful and informative failure recovery.
- Support the ability to collect performance statistics.

Submitted library files must export and properly implement the five functions defined in this section. NIST’s test harness will link to the libraries and call the exported functions. The test process can broadly be separated into four steps:

1. Construction of the enrollment templates.
2. Construction of the enrollment database.
3. Construction of the search templates.
4. Searching against the enrollment database.

Table 3 outlines the basic program flow in somewhat greater detail. The API documentation was auto-generated using Doxygen [2] with irex.h as input from the validation package.

### Table 3: Program Flow

<table>
<thead>
<tr>
<th>Stage</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
**Enrollment**

initializeTemplates()
Allows the implementation to perform initialization procedures prior to template creation.

*Provides the implementation with advance knowledge of the number of images that will be enrolled as well as read-only access to a participant-supplied configuration directory.*

createTemplate()
Creates an enrollment template from one or more iris images.

*The implementation must be able to handle multiple calls to this function from multiple instances of the calling application.*

createEnrollmentDatabase()
Constructs an enrollment database from a collection of enrollment templates.

*This function allows post-enrollment book-keeping, normalization, and other statistical processing of the templates. The implementation should populate the specified directory with everything necessary to perform searches against the database.*

**NOTE:** The test harness is not guaranteed to call createEnrollmentDatabase() within the same executable as the above functions.

**Pre-search**

initializeTemplates()
Allows the implementation to perform initialization procedures prior to template creation.

*The implementation is allowed read-only access to the enrollment directory at this stage.*

createTemplate()
Creates a search template from one or more iris images.

*The implementation must be able to handle multiple calls to this function from multiple instances of the calling application.*

**Search**

initializeIdentification()
Prepares the implementation for searches against the enrollment database.

*The implementation is allowed to read data (e.g. templates) from the enrollment database directory and load them into memory.*

identify()
Searches a template against the enrollment database and returns an ordered list of candidates.

### 4.1 Template Construction

- `int32_t initializeTemplates (const uint8_t type, const std::string &configDirectory="")`
  *Initialization function, called once prior to one or more calls to createTemplate().*
- `int32_t createTemplate (const uint8_t type, std::vector< IrisImage > &irides, std::vector< uint8_t > &templateData)`
API Specification

Generates a template from a vector of iris images.

**initializeTemplates()**

```cpp
int32_t IREX::initializeTemplates (  
    const uint8_t type,  
    const std::string & configDirectory = "" )
```

Initialization function, called once prior to one or more calls to `createTemplate()`.

The implementation shall tolerate execution of multiple calls to this function from different processes running on the same machine. If participants wish to use the optional `configDirectory` parameter, they must say so in documentation accompanying their submission. NIST will debug if a call to this function returns a non-zero value, contacting the participant if necessary.

**Parameters**

<table>
<thead>
<tr>
<th>in</th>
<th>type</th>
<th>About to create enrollment (type=0) or search (type=1) templates.</th>
</tr>
</thead>
<tbody>
<tr>
<td>in</td>
<td>configDirectory</td>
<td>An (optional) absolute path to a read-only directory containing participant-supplied configuration parameters and/or runtime data files.</td>
</tr>
</tbody>
</table>

**Returns**

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Success.</td>
</tr>
<tr>
<td>5</td>
<td>The configuration data is missing, unreadable, or in an unexpected format.</td>
</tr>
<tr>
<td>Other</td>
<td>Participant-defined failure (must provide documentation).</td>
</tr>
</tbody>
</table>

**createTemplate()**

```cpp
int32_t IREX::createTemplate (  
    const uint8_t type,  
    std::vector< IrisImage > & irides,  
    std::vector< uint8_t > & templateData )
```

Generates a template from a vector of iris images.

The implementation must be able to handle iris images having arbitrary pixel dimensions, although primary NIST tests are expected to only operate over images that are 640x480 or 640x512. If a return value of 100 or greater is returned, NIST will attempt to debug, contacting the participant if necessary.

Each IrisImage has an optional `quality` field that participants are encouraged to fill in. As per ISO/IEC 29794-6: Biometric Sample Quality, values should be between 0 and 100 with higher values indicating better quality, or 255 indicating an inability to provide a quality score. Implementations are not required to fill in this parameter but it would be appreciated by NIST.

When specified, the iris boundary variables provide estimates of the limbus center (`limbusCenterX`, `limbusCenterY`) and pupil (`pupilRadius`) and limbus (`limbusRadius`) radii. The estimates should be accurate to within a few pixels. When left unspecified, the participant is encouraged to fill in these values, as it can assist with debugging, but doing so is optional.

Each IrisImage in `irides` represents a single iris image (left or right). Implementations must support the following scenarios:

1. `irides` contains a single iris image.
2. \textit{irides} contains one left and one right iris.

3. \textit{irides} contains several images of the same iris.

4. \textit{irides} contains $N$ images of the left iris and $N$ images of the right iris.

For scenarios 2-4 the \texttt{eye} parameter for each \texttt{IrisImage} in \textit{irides} will always be set to either 1 (\texttt{left}) or 2 (\texttt{right}) and never 0 (\texttt{unknown / undefined}). Scenario 2 represents the most common operational use case and is likely to be the most tested.

### Parameters

<table>
<thead>
<tr>
<th>in</th>
<th>type</th>
<th>Create an enrollment (type==0) or search (type==1) template.</th>
</tr>
</thead>
<tbody>
<tr>
<td>in</td>
<td>\textit{irides}</td>
<td>The iris images from which to create the template.</td>
</tr>
<tr>
<td>out</td>
<td>templateData</td>
<td>Template generated from the iris samples. The template's format is proprietary and NIST will not access any part of it other to pass it to \texttt{createDatabase()} and possibly store it temporarily.</td>
</tr>
<tr>
<td>out</td>
<td>quality</td>
<td>An \texttt{optional} quality score predicting comparison performance of the template. Values should be between 0 and 100 with higher values indicating better quality, or 255 indicating a failure to calculate a quality score.</td>
</tr>
</tbody>
</table>

### Returns

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Success.</td>
</tr>
<tr>
<td>1</td>
<td>Failure to find the iris.</td>
</tr>
<tr>
<td>2</td>
<td>The input data is in an incorrect or unrecognized format.</td>
</tr>
<tr>
<td>$10 \leq \text{ret} &lt; 100$</td>
<td>Participant-defined \texttt{soft failure}. Soft failures allow the participant to provide more descriptive output on why a matchable template could not be created. The participant must provide documentation for these error codes.</td>
</tr>
<tr>
<td>$100 \leq \text{ret}$</td>
<td>Participant-defined \texttt{hard failure}. Hard failures should indicate unexpected events that require debugging, as they might compromise the validity of test results. The participant must provide documentation for these error codes.</td>
</tr>
</tbody>
</table>

4.2 Enrollment Database Construction

- \texttt{int32\_t createDatabase (const std::string &enrollmentDirectory, const std::vector< DatabaseEntry > &templates)}

  \textit{Function to create an enrollment database to search against.}

\texttt{createDatabase()}

\texttt{int32\_t IREX::createDatabase ( const std::string & enrollmentDirectory, const std::vector< DatabaseEntry > & templates )}

Function to create an enrollment database to search against.

Enrollment database creation shall be performed after all enrollment processes are complete. It should populate the contents of the enrollment directory with everything that is necessary to perform searches
against it. This function allows post-enrollment book-keeping, normalization, and other statistical pro-
cessing of the generated templates. It should tolerate being called multiple times, although subsequent
calls should probably not do anything.

NIST will debug if a call to this function returns a non-zero value. The NIST test harness will never
knowingly enroll the same iris under two different identifiers.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>enrollmentDirectory</td>
<td>An absolute path to the top-level directory in which the enrollment database will reside. The implementation will have read and write access to this directory.</td>
</tr>
<tr>
<td>templates</td>
<td>The vector of enrollment templates that should comprise the enrollment database. The implementation should store these templates in the enrollment directory.</td>
</tr>
</tbody>
</table>

Returns

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Success.</td>
</tr>
<tr>
<td>2</td>
<td>One or more enrollment templates are in an incorrect format.</td>
</tr>
<tr>
<td>4</td>
<td>An operation on the enrollment directory failed.</td>
</tr>
<tr>
<td>Other</td>
<td>Participant-defined failure (must provide documentation).</td>
</tr>
</tbody>
</table>

4.3 Searching

- int32_t initializeIdentification (const std::string &enrollmentDirectory, const std::string &configDirectory="")
  Initialization function, to be called once prior to one or more calls to identify().
- int32_t identify (const std::vector<uint8_t> &searchTemplate, const uint32_t numCandidates, std::vector<Candidate> &candidates)
  Searches a template against the enrollment database and returns a list of candidates.

initializeIdentification()

int32_t IREX::initializeIdentification ( 
  const std::string & enrollmentDirectory, 
  const std::string & configDirectory = ""
)

Initialization function, to be called once prior to one or more calls to identify().

The function may use this function to read data (e.g. templates) from the enrollment directory and load it into memory. NIST will debug if a call to this function returns a non-zero value, contacting the participant if necessary.

If participants wish to use the configDirectory parameter, they must say so in documentation accompanying their submission.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>enrollmentDirectory</td>
<td>The top-level directory in which the enrollment data was placed when finalizeEnrollment() was called.</td>
</tr>
<tr>
<td>configDirectory</td>
<td>An (optional) absolute path to a read-only directory containing participant-supplied configuration parameters and/or runtime data files.</td>
</tr>
</tbody>
</table>
### Returns

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Success.</td>
</tr>
<tr>
<td>4</td>
<td>An operation on the enrollment directory failed.</td>
</tr>
<tr>
<td>5</td>
<td>The configuration data is missing, unreadable, or in an unexpected format.</td>
</tr>
<tr>
<td>Other</td>
<td>Participant-defined failure (must provide documentation).</td>
</tr>
</tbody>
</table>

### identify()

```c
int32_t IREX::identify ( 
    const std::vector<uint8_t> & searchTemplate, 
    const uint32_t numCandidates, 
    std::vector<Candidate> & candidates )
```

Searches a template against the enrollment database and returns a list of candidates.

NIST will typically set the candidate list length to operationally feasible values (e.g. 20), but may decide to extend it to values that approach the size of the enrollment database.

#### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>searchTemplate</code></td>
<td>A search template generated by a call to <code>createTemplate()</code>.</td>
</tr>
<tr>
<td><code>numCandidates</code></td>
<td>The length of the candidate list array to output.</td>
</tr>
<tr>
<td><code>candidates</code></td>
<td>An array (of length <code>numCandidates</code>) of candidates. Each candidate shall be populated by the implementation and shall be sorted in ascending order of distance score (i.e. the most similar entry shall appear first).</td>
</tr>
</tbody>
</table>

#### Returns

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Success.</td>
</tr>
<tr>
<td>3</td>
<td>The input template does not contain matchable information.</td>
</tr>
<tr>
<td>10 ≤ ret &lt; 100</td>
<td>Participant-defined soft failure. Soft failures simply allow the participant to provide more descriptive output on why the search could not produce valid results. The participant must provide documentation of these error codes.</td>
</tr>
<tr>
<td>100 ≤ ret</td>
<td>Participant-defined hard failure. Hard failures should indicate unexpected events that require debugging, as they might compromise the validity of test results. The participant must provide documentation of these error codes.</td>
</tr>
</tbody>
</table>

### 4.4 Supporting Data Structures

This section describes the data structures used by the API.

**IrisImage Struct**

Holds image data for an iris.
Public Attributes

- **uint16 t width**
  Image width in pixels.

- **uint16 t height**
  Image height in pixels.

- **std::vector< uint8 t > data**
  Pointer to image raster data (RGBRGBRGB... for 24-bit images).

- **uint8 t depth**
  Bit depth, 8 for grayscale or 24 for RGB visible spectrum images.

- **uint8 t eye**
  The eye label (0 = undefined, 1 = right eye, 2 = left eye).

- **uint16 t wavelength = 0**
  Wavelength (in nanometers) at which the image was acquired (0=unspecified).

- **uint8 t quality = 255**
  An optional quality score that participants are encouraged to fill in.

- **uint16 t limbusCenterX = 0**
  Approximate horizontal center of the limbus in pixels (0=unspecified).

- **uint16 t limbusCenterY = 0**
  Approximate vertical center of the limbus in pixels (0=unspecified).

- **uint16 t pupilRadius = 0**
  Approximation of pupil radius in pixels (0=unspecified).

- **uint16 t limbusRadius = 0**
  Approximation of limbus radius in pixels (0=unspecified).

Holds image data for an iris.

Member Data Documentation

**wavelength**  
**uint16 t wavelength = 0**

Wavelength (in nanometers) at which the image was acquired (0=unspecified).

If this value is unspecified (as will be the case for the OPS IV dataset), it can be assumed that the image was acquired by a standard iris camera at near infrared wavelengths.

**quality**  
**uint8 t quality = 255**

An optional quality score that participants are encouraged to fill in.

The quality score should predict the comparison performance of templates generated from this iris image. As per ISO/IEC 29794-6: Biometric Sample Quality, values should be between 0 and 100 with higher values indicating better quality, or 255 indicating an inability to calculate a quality score. Again, implementations are not required to fill in this value but it would be appreciated by NIST.

**limbusCenterX**  
**uint16 t limbusCenterX = 0**

Approximate horizontal center of the limbus in pixels (0=unspecified).

When specified, the iris boundary variables provide estimates of the limbus center (`limbusCenterX`, `limbusCenterY`) and pupil (`pupilRadius`) and limbus (`limbusRadius`) radii. The estimates should be accurate to within a few pixels.

When left unspecified, the participant is encouraged to fill these values in, as it can assist with debugging, but doing so is optional.

**Candidate Struct**

Stores a single candidate (returned by `identify()`).
API Specification

Public Attributes

- std::string id = "NA"
  A unique identifier assigned to this template.
- double distance = HUGE_VAL
  Non-negative measure of dissimilarity (aka distance) between the searched template and the candidate.

Stores a single candidate (returned by identify()).

DatabaseEntry Struct

An enrollment template with associated unique identifier (see createDatabase()).

Public Attributes

- std::vector<uint8_t> enrollmentTemplate
  The enrollment template.
- std::string id
  Unique identifier assigned to this template.

An enrollment template with associated unique identifier (see createDatabase()).
5 References


Application to Participate in Iris Exchange (IREX) X

1. **Who Can participate**
   
   1.1. Iris recognition researchers and developers from industry, research institutions, and academia are eligible to participate in Iris Exchange X: Ongoing Evaluation of Iris Recognition - hereafter referred to as IREX X.
   
   1.2. Signatories to this document, Application to Participate in Iris Exchange X (Agreement), acknowledge that they understand the results of this test will be published with attribution to their Organization.

2. **How to Participate**
   
   2.1. To participate, an Organization must complete this form and mail it to the designated address. The
   
   • Responsible Party is an individual with the authority to commit the Organization to the terms in this Agreement.
   
   • Point of Contact is an individual within the Organization with detailed knowledge of the submitted software Implementation.
   
   • The Responsible Party and Point of Contact may be the same person.
   
   2.2. Upon receipt of the signed agreement, the Organization will be classified as a Participant in IREX X.
   
   2.3. The Participant shall submit an iris recognition Implementation to NIST that is conformant with the Concept, Evaluation Plan, and API Specification associated with the test, available on the IREX X website https://www.nist.gov/itl/iad/image-group/ongoing-irex.
   
   2.4. Transmission of Implementations to NIST must follow the submission procedures detailed in the CONOPS and API specification document. This involves the encryption of all proprietary software submitted to NIST. The encryption procedure can be found at http://www.nist.gov/itl/iad/ig/encrypt.cfm.
   
   2.5. The Participant may withdraw from IREX X at any time before their Implementation is received by NIST, without their participation or withdrawal being documented on the IREX X website.
   
   2.6. Organizations only need to mail this Agreement the first time they submit an Implementation to IREX X. Organizations need not mail a new application each time they submit an Implementation.

3. **Point of Contact**
   
   3.1. The IREX X Liaison is the U.S. Government point of contact for IREX X. All questions should be directed to irex@nist.gov, which will be received by the IREX X Liaison and other IREX personnel.

4. **Release of Results**
   
   4.1. After successful completion of testing, NIST will publish the results along with the Organization's name to the IREX X website.
   
   4.2. The Point of Contact will be notified once results are posted.
   
   4.3. References to results in IREX X shall be accompanied by the phrase “Results presented in IREX do not constitute an endorsement, recommendation, or favoring of any particular system, product, or service by the U.S. Government.” A reference to the IREX website is also requested.
   
   4.4. All published results are provided in good faith and NIST takes no legal responsibility for the accuracy of the information provided. In the event that errors are discovered, NIST will re-run prior tests to resolve those errors.
5. **Legal**

5.1. To the extent allowable by Federal law, NIST agrees to protect Implementations as business proprietary information by using same degree of care, but no less than a reasonable degree of care, to prevent the unauthorized use, dissemination or publication of the Proprietary Information as NIST uses to protect its own confidential information of a like nature. NIST agrees not to transfer any Implementations to any third party without the prior written permission of the Participant.

5.2. These provisions are consistent with and do not supersede, conflict with, or otherwise alter the employee obligations, rights, or liabilities created by existing statute or Executive order relating to (1) classified information, (2) communications to Congress, (3) the reporting to an Inspector General of a violation of any law, rule, or regulation, or mismanagement, a gross waste of funds, an abuse of authority, or a substantial and specific danger to public health or safety, or (4) any other whistleblower protection. The definitions, requirements, obligations, rights, sanctions, and liabilities created by controlling Executive orders and statutory provisions are incorporated into this Agreement and are controlling.

5.3. Any data obtained during IREX X, as well as any documentation required by NIST from the Participant (except the Implementation), becomes the property of NIST. The Participant will not acquire a proprietary interest in the data and/or submitted documentation. Any data or documentation that qualifies as business proprietary information, as defined by the Freedom of Information Act (5 USC Section 552) will be treated as confidential in accordance with Section 2, and will only be used for the purposes of IREX testing.

5.4. Participant agrees that they will not file any IREX X related claim against IREX sponsors, supporters, staff, contractors, or agency of the U.S. Government, or otherwise seek compensation for any equipment, materials, supplies, information, travel, labor and/or other Participant-provided services.

5.5. The U.S. Government is not bound or obligated to follow any recommendations requested by the Participant. The U.S. Government is not bound, nor obligated in any way, to give any special consideration to the Participant on future contracts.

5.6. By signing this Agreement, the Participant acknowledges that they understand any test details and/or modifications that are provided in the IREX X website supersede the information on this Agreement.
Application to Participate in Iris Exchange (IREX) X

Please mail this completed form, along with attached business cards from both signing parties, to:

IREX X Test Liaison
National Institute of Standards and Technology
Information Access Division (774.03)
100 Bureau Drive, Mailstop 8940
Gaithersburg, MD 20899-8940

This Application must be mailed. Scanned documents sent as email attachments will not be accepted. Please send an email to irex@nist.gov once you have mailed your application. Upon receipt, NIST will respond with a confirmation.

The Participant must provide a Public Key per the instructions for the transmission of encrypted content to NIST at http://www.nist.gov/itl/iad/ig/encrypt.cfm. Alternatively, the Participant may write "faxed" in the box below and fax the public key to the IREX X Test Liaison at (301) 975-5287.

<table>
<thead>
<tr>
<th>Participant Public Key</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NIST Public Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>2284 D56A F01B D81D 6F2A 16BE B648 74EA DBA5 F3A8</td>
</tr>
</tbody>
</table>

With my signature, I hereby request consideration as a Participant in IREX X, and I authorize my Organization to participate according to the rules and limitations listed in this document.

With my signature, I also state that I have the authority to accept the terms stated in this Agreement.

<table>
<thead>
<tr>
<th>Signature of Responsible Party</th>
<th>Email Address</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Signature of Point of Contact</th>
<th>Email Address</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
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