Text Recognition Algorithm Independent Test (TRAIT)

An Evaluation Activity under the DHS Science & Technology Child Exploitation Image Analytics Program (CHEXIA)

Homeland Security

Science and Technology

Concept, Evaluation Plan and API

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Provisional Timeline of the TRAIT 2016 Evaluation

Phase 0 API Development	2015-10-05	Draft evaluation plan
	2015-11-15	Final evaluation plan
Phase 1	2015-12-01	Participation starts: Algorithms may be sent to NIST
	2016-02-08	**Last day for submission of algorithms to Phase 1**
	2016-03-07	Interim results released to Phase 1 participants
Phase 2	**2016-06-12**	**Last day for submission of algorithms to Phase 2**
	2016-07-12	Interim results released to Phase 2 participants
Phase 3	**2016-10-31**	**Last day for submission of algorithms to Phase 3**
	2017-Q1	Release of final public report

Updates since the last version are highlighted in green.

Major updates for Phase 3

- Removal of algorithm time constraints for text detection and recognition in Section 1.19.
- Addition of providing location in the form of a bounding box to algorithms for Class B – Image-to-text with provided location information in Section 3.2.
- Additional test data characteristics in Section 1.4.
- Addition of algorithm support for detection and recognition of URLs in Section 3.3.2.5.
- Phase 3 submission deadline is now October 31, 2016.

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1. TRAIT

1.1. Scope

This document establishes a concept of operations and C++ API for evaluation of text-in-image detection and recognition algorithms submitted to NIST's TRAIT program. See http://www.nist.gov/itl/iad/ig/trait-2016.cfm for latest documentation.

TRAIT proceeds as follows. Algorithm developers send compiled C++ libraries to NIST. NIST executes those algorithms on sequestered imagery that has been made available to NIST by, for example, other US Government agencies.

1.2. Audience

This document is aimed at universities, commercial entities and other research organizations possessing a capability to detect and recognize unconstrained text in still images. There is no requirement for real-time or streaming-mode processing. An example image appears in Figure 1. It is intended only as an example of out-of-plane text, not as some representation of widely varying test data.

Figure 1 – Example of inputs and outputs

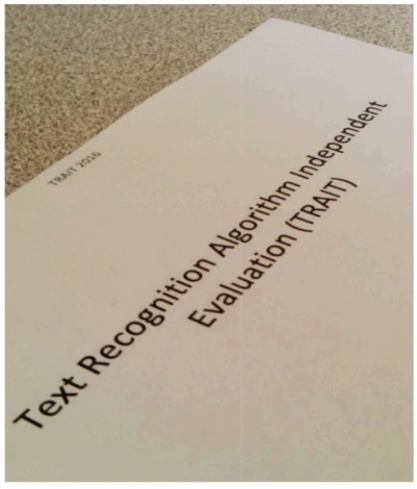
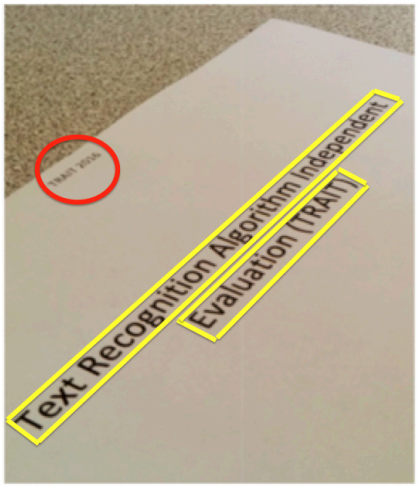
A simple example of out-of-plane text.	Input image showing geometric markup in yellow, and missed detection in red.	Possible Output text and (dummy, nominal) coordinates
		First string at very top of page is missed Text Recognition Algorithm Independent (x,y) = (10,10),(10,100),(20,100),(20,10),(10,10) Evaluation (TRAIT) (x,y) = (30,30),(30,60),(40,60),(30,40),(30,30)

Figure 2 – Example of input with provided location information and outputs

A simple example of out-of-plane text with provided location information marked by the yellow lines. NOTE: When location information is provided to a text recognition algorithm, we provide a simple line instead of a polygon. The reason for this is that our ground truthing process put emphasis on maximizing the number of images i.e. high speed, high volume. This meant that drawing bounding box polygons, which is slow, was deprecated in favor of drawing lines. Implementations that require polygons for recognition will have to estimate that information starting from the provided line.	Possible Output text corresponding to provided locations
	IN CASE OF FIRE DO NOT USE ELEVATOR USE EXIT STAIRS

Organizations will need to implement the API defined in this document. Participation is open worldwide. There is no charge for participation. While NIST intends to evaluate technologies that could be readily made operational, the test is also open to experimental, prototype and other technologies.

NIST is particularly interested to evaluate prototypes that have proven useful in prior evaluations organized underneath the ICDAR conferences (http://2015.icdar.org/program/competitions/) particularly the Robust Reading efforts (http://rrc.cvc.uab.es/)

1.3. Market drivers

This test is intended to support a plural marketplace of text recognition systems. Our primary driver is to support forensic investigations of digital media. Specifically, to allow linking of child exploitation events that occur in a common location, or that share other textual clues.

1.4. Test data

NIST will run submitted algorithms on several sequestered datasets available to NIST.

The primary dataset is an operational child exploitation collection containing illicit pornographic images. The images are present on digital media seized in criminal investigations. The files include children who range in age from infant through adolescent. Their faces are the subject of a separate face recognition evaluation and development effort (CHEXIA-FACE 2016). Many of the images contain geometrically unconstrained text. This text is human-legible and sometimes has investigational value. Such text is visible on certificates, posters, logos, uniforms, sports apparel, computer screens, business cards, newspapers, books lying on tables, cigarette packets and a long list of more rare objects. There will also be instances where watermarks or logos were post-processed into the image.

The text is most commonly in English with French, Spanish, German and Cyrillic present in significant quantity. We do not intend to test non-Roman alphabets. Images contain text on clothing, low-resolution text, exotic fonts, symbols, and numbers.

URLs: A quarter of the test images contain URLs, often in-plane, post-processed into the image. URLs can provide important leads to an investigation. As such, a new function to specifically evaluate processing of URLs has been added to this API document. See Sections 3.3.2.5 and 1.12 for details.

These images are of interest to NIST's partner law enforcement agencies that seek to employ text recognition in investigating this area of serious crime. The primary applications are identification of previously known victims and suspects, as well as detection of new victims and suspects. The presence of text may allow a location to be identified or to generate leads.

1.5. Offline testing

TRAIT is intended to mimic operational reality. As an offline test intended to assess the core algorithmic capability of text detection and recognition algorithms, it does not extend to real-time transcription of live image sources. Offline testing is attractive because it allows uniform, fair, repeatable, and efficient evaluation of the underlying technologies. Testing of implementations under a fixed API allows for a detailed set of performance related parameters to be measured. The algorithms will be run only on NIST machines by NIST employees.

1.6. Phased testing

To support development, TRAIT will be conducted in three phases. In each phase, NIST will evaluate implementations on a first-come-first-served basis and will return results to providers as expeditiously as possible. The final phase will result in public reports. Providers may submit revised SDKs to NIST only after NIST provides results for the prior SDK and invites further submission. The frequency with which a provider may submit SDKs to NIST will depend on the times needed for developer preparation, transmission to NIST, validation, execution and scoring at NIST, and developer review and decision processes.

For the schedule and number of SDKs of each class that may be submitted, see sections 1.10 and 1.11.

1.7. Interim reports

The performance of each SDK will be reported in a "score-card". This will be provided to the participant and not publicly. The feedback is intended to facilitate development. Score cards will: be machine generated (i.e. scripted); be provided to participants with identification of their implementation; include timing, accuracy and other performance results; include results from other implementations, but will not identify the other providers; be expanded and modified as revised implementations are tested, and as analyses are implemented; be produced independently of the status of other providers' implementations; be regenerated on-the-fly, usually whenever any implementation completes testing, or when new analysis is added.

NIST does not intend to release these test reports publicly. NIST may release such information to the U.S. Government test sponsors; NIST will request that agencies not release this content.

1.8. Final reports

NIST will publish one or more final public reports. NIST may also publish: additional supplementary reports (typically as numbered NIST Interagency Reports); in other academic journals; in conferences and workshops (typically PowerPoint).

Our intention is that the final test reports will publish results for the best-performing implementation from each participant. Because "best" is ill defined (accuracy vs. processing time, for example), the published reports may include results for other implementations. The intention is to report results for the most capable implementations (see section 1.12, on metrics). Other results may be included (e.g. in appendices) to show, for example, examples of progress or tradeoffs. IMPORTANT: **Results will be attributed to the providers.**

1.9. Application scenarios

The test will include detection and recognition tasks for still images. As described in Table 1, the test is intended to support operations in which an automated text recognition engine yields text that can be indexed and retrieved using mainline text retrieval engines.

Table 1 – Subtests supported under the TRAIT 2016 activity

#		A	B	C
1.	Aspect	Image-to-location	Image-to-text with provided location information	Image-to-text-and-location
2.	Languages	Mostly English. Some French, Spanish and German. While some Cyrillic and Chinese appear also, evaluation will be confined to English roman alphabets only.		
3.	Input	Image(s)	Image(s) and location(s) of text	Image(s)
4.	Output	Given an input image, output detected locations of text. This does not require the algorithm(s) to produce strings of text.	Given an input image and location(s) of text in the image, output strings of text.	Given an input image, output strings of text along with their corresponding locations in the image.

NOTE 1: The vast majority of images are color. The API supports both color and greyscale images.

NOTE 2: For the operational datasets, it is not known what processing was applied to the images before they were archived. So, for example, we do not know whether gamma correction was applied. NIST considers that best practice, standards and operational activity in the area of image preparation remains weak.

1.10. Options for participation

The following rules apply:

- A participant must properly follow, complete and submit the TRAIT 2016 Participation Application (see Annex A). This must be done once, not before December 1, 2015. It is not necessary to do this for each submitted SDK.
- Participants may submit class C algorithms only if at least 1 class B algorithm is also submitted.
- All submissions shall implement exactly one of the functionalities defined in Table 2. A library shall not implement two or more classes.

Table 2 – TRAIT 2016 classes of participation

Function	Image-to-location	Image-to-text with provided location information	Image-to-text-and-location
Class label	A	B	C
Must also submit to class			B
API requirements	3.1	3.2	3.3

1.11. Number and schedule of submissions

The test is conducted in three phases, separated by a few months. The maximum total (i.e. cumulative) number of submissions is regulated in Table 3.

Table 3 – Cumulative total number of algorithms, by class

#	Phase 1	Total over Phases 1 + 2	Total over Phases 1 + 2 + 3
Class A: Image-to-location	2	4	6
Class B: Image-to-text with provided location information	2	4	6
Class C: Image-to-text-and-location	2	4	6

The numbers above may be increased as resources allow.

NIST cannot conduct surveys over runtime parameters.

1.12. Core accuracy metrics

Recognition: The evaluation will be performed on the text results provided by each system. We intend to state text recognition accuracy with at least an edit distance such as the Word Error Rate (WER) [1.12a] between the reference text and text provided by the system for each line. WER is calculated with the edit distance with equal cost of deletions, substitutions, and insertions and finally normalize the edit distance by the number of characters in the ground truth words.

[1.12a] J. Fiscus, J. Ajot, N. Radde, and C. Laprun, *Multiple Dimension Levenshtein Edit Distance Calculations for Evaluating Automatic Speech Recognition Systems During Simultaneous Speech*, Proceedings of LREC, 2006. http://www.itl.nist.gov/iad/mig/publications/storage_paper/lrec06_v0_7.pdf

Detection: The text detection task will be evaluated, somewhat similar to prior open evaluations [1.12b]. However, in our case the ground truth text is defined by both bounding boxes and line segments. Hence our methodology will be based on the intersection of ground truth and detection bounding boxes and the matching distance between the ground truth lines and the detection-bounding boxes as the criteria.

[1.12b] C. Wolf and J.-M. Jolion. Object count/Area Graphs for the Evaluation of Object Detection and Segmentation Algorithms, International Journal on Document Analysis and Recognition, 8(4):280-296, 2006. http://liris.cnrs.fr/christian.wolf/software/deteval/index.html

URLs: Operationally, the most pertinent part of a URL is the domain name. In evaluating URL text recognition, we may consider the accuracy impact of ignoring punctuation, (e.g., {. , : , /, ? , @, etc.}), protocol text, (e.g., http, https, etc.), and top level domain words (e.g., com, org, info, net, etc.).

1.13. Reporting computational efficiency

NIST will also report timing statistics for all core functions of the submitted SDK implementations. All timing tests will be executed on unloaded machines running a single process.

1.14. Hardware specification

NIST intends to execute the software on Dual Intel Xeon E5-2695 3.3 GHz CPUs (14 cores each; 56 logical CPUs total) with Dual NVIDIA Tesla K40 Graphics Processing Units (GPUs). NIST will respond to prospective participants' questions on the hardware by amending this section.

1.15. Operating system, compilation, and linking environment

The operating system that the submitted implementations shall run on will be released as a downloadable file accessible from http://nigos.nist.gov:8080/evaluations/ which is the 64-bit version of CentOS 7 running Linux kernel 3.10.0.

For this test, Windows machines will not be used. Windows-compiled libraries are not permitted. All software must run under Linux.

NIST will link the provided library file(s) to our C++ language test drivers. Participants are required to provide their library in a format that is linkable using the C++11 compiler, g++ version 4.8.3.

A typical link line might be

```
g++ -std=c++11 -I. -Wall -m64 -o trait16test  trait16test.cpp  -L.  –ltrait2016_Enron_A_07
```

The Standard C++ library should be used for development. The prototypes from this document will be written to a file "trait2016.h" which will be included via

```
#include <trait2016.h>
```

The header and source files will be made available to implementers at http://nigos.nist.gov:8080/trait2016.

NIST will handle all input of images via the JPEG and PNG libraries, sourced, respectively from http://www.ijg.org/ and see http://libpng.org.

All compilation and testing will be performed on x86 platforms. Thus, 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 later on (e.g., symbol name and calling convention mismatches, incorrect binary file formats, etc.).

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 upon prior approval by the Test Liaison. Libraries to access the GPU must be provided to NIST as a part of the algorithm submission package.

1.16. Software and Documentation

1.16.1. SDK Library and Platform Requirements

Participants shall provide NIST with binary code only (i.e., no source code). Header files (".h") are allowed, but these shall not contain intellectual property of the company nor any material that is otherwise proprietary. The SDK should be submitted in the form of a dynamically linked library file. A separate library file shall be submitted for each class of participation (i.e., CLASS_A, CLASS_B, CLASS_C).

The core library shall be named according to Table 4. Additional shared object library files may be submitted that support this "core" library file (i.e. the "core" library file may have dependencies implemented in these other libraries).

Intel Integrated Performance Primitives (IPP) libraries are permitted if they are delivered as a part of the developer-supplied library package. It is the provider's responsibility to establish proper licensing of all libraries. The use of IPP libraries shall not prevent running on CPUs that do not support IPP. Please take note that some IPP functions are multithreaded and threaded implementations may complicate comparative timing.

Table 4 – Implementation library filename convention

Form	libTRAIT2016_provider_class_sequence.ending				
Underscore delimited parts of the filename	libTRAIT2016	provider	class	sequence	ending
Description	First part of the name, required to be this.	Single word name of the main provider EXAMPLE: Enron	Function classes supported in Table 2. EXAMPLE: C	A two digit decimal identifier to start at 00 and increment by 1 every time a library is sent to NIST. EXAMPLE: 07	.so
Example	libTRAIT2016_Enron_C_07.so				

NIST will report the size of the supplied libraries.

1.16.2. Configuration and developer-defined data

The implementation under test may be supplied with configuration files and supporting data files. The total size of the SDK, that is all libraries, include files, data files and initialization files shall be less than or equal to 1 073 741 824 bytes = 1024^3 bytes.

NIST will report the size of the supplied configuration files.

1.16.3. Submission folder hierarchy

Participant submissions should contain the following folders at the top level

- lib/ - contains all participant-supplied software libraries
- config/ - contains all configuration and developer-defined data
- doc/ - contains any participant-provided documentation regarding the submission

1.16.4. Installation and Usage

The SDK must install easily (i.e., one installation step with no participant interaction required) to be tested and shall be executable on any number of machines without requiring additional machine-specific license control procedures or activation.

The SDK shall neither implement nor enforce any usage controls or limits based on licenses, number of executions, presence of temporary files, etc. The SDKs shall remain operable with no expiration date.

Hardware (e.g., USB) activation dongles are not acceptable.

1.16.5. Documentation

Participants may provide documentation of the SDK and detail any additional functionality or behavior beyond that specified here. The documentation might include developer-defined error or warning return codes. The documentation shall not include any intellectual property.

1.17. Runtime behavior

1.17.1. Interactive behavior

The implementation will be tested in non-interactive “batch” mode (i.e., without terminal support). Thus, the submitted library shall:

- Not use any interactive functions such as graphical user interface (GUI) calls or any other calls which require terminal interaction, e.g., reads from “standard input”.
- Run quietly, i.e., it should not write messages to "standard error" and shall not write to “standard output”.
- If requested by NIST for debugging, include a logging facility in which debugging messages are written to a log file whose name includes the provider and library identifiers and the process PID.

1.17.2. Exception Handling

The application should include error/exception handling so that in the case of a fatal error, the return code is still provided to the calling application.

1.17.3. External communication

Processes running on NIST hosts shall not side-effect the runtime environment in any manner, except for memory allocation and release. Implementations shall not write any data to an external resource (e.g., server, file, connection, or other process), nor read from such. If detected, NIST will take appropriate steps, including but not limited to, cessation of evaluation of all implementations from the supplier, notification to the provider, and documentation of the activity in published reports.

1.17.4. Stateless behavior

All components in this test shall be stateless, except as noted. This applies to text detection, recognition and transcription. 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 will take appropriate steps, including but not limited to, cessation of evaluation of all implementations from the supplier, notification to the provider, and documentation of the activity in published reports.

1.18. Threaded computations

All implementations should run without threads, or with exactly one single process. This allows NIST to parallelize the test by dividing the workload across multiple cores and multiple machines. The implementation shall be tolerant of NIST running N > 2 processes concurrently. NIST's calling applications are single-threaded.

1.19. Time limits

~~Given a 12 megapixel input image, the text detection and recognition software should execute in less than 10 seconds~~.

2. Data structures supporting the API

2.1. Namespace

All data structures and API interfaces/function calls will be declared in the `TRAIT2016` namespace.

2.2. Overview

This section describes separate APIs for the core text detection/recognition applications described in section 1.9. All SDK's submitted to TRAIT 2016 shall implement the functions required by the rules for participation listed before Table 2.

2.3. Requirement

TRAIT 2016 participants shall submit an SDK, which implements the relevant C++ functions (per class) as specified in Table 2. C++ was chosen in order to make use of some object-oriented features.

2.4. File formats and data structures

2.4.1. Overview

In this text detection and recognition test, the input data is a still image.

2.4.2. Data structures for encapsulating a single image

An image is provided to the algorithm using the data structure of Table 5.

Table 5 – Struct representing a single image

	C++ code fragment	Remarks
1.	`struct Image`	
2.	`{`	
3.	`uint16_t image_width;`	Number of pixels horizontally
4.	`uint16_t image_height;`	Number of pixels vertically
5.	`uint8_t image_depth;`	Number of bits per pixel. Legal values are 8 and 24.
6.	`uint8_t *data;`	Pointer to raster scanned data. Either RGB color or intensity. If image_depth == 24 this points to 3WH bytes RGBRGBRGB... If image_depth == 8 this points to WH bytes `IIIIIII`
7.	`};`	

2.4.3. Data structures for reporting detected text

Implementations should report locations of text in each image using the structure of the table below.

Table 6 – Structure representing a point in 2D coordinates

	C++ code fragment	Remarks
1.	`struct Coordinate`	
2.	`{`	
3.	`uint16_t x;`	x-value
4.	`uint16_t y;`	y-value
5.	`};`	

Table 7 – Location Types

	Location Type as C++ enumeration	Meaning
	`enum class LocationType {`	

1.	/* Input only */ Line=1,	Coordinates of line segments drawn through the centroids of the text. There will be N=2 points with coordinates giving the endpoints. This type is used for input to the implementation only, i.e. Class B (Image-to-text with provided location).
2.	/* Input and Output */ Polygon=2	In **reading, clockwise order**, the coordinates of a closed polygon drawn around the line of text, where the coordinates of the first and last points in the polygon are the same. This type is used for input , i.e. Class B (Image-to-text with provided location) and output from the implementation, i.e. Class A (Image-to-location) and Class C (Image-to-text-and-location).
3.	};	

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340 **Table 8 – Data structure for location information in an image**

	C++ code fragment	Remarks
1.	struct Location	
2.	{	
3.	std::vector<Coordinate> points;	Coordinates representing the location of the text
4.	LocationType type;	For Class B (Image-to-text with provided location), this will provide the location information for text in the form of a line through the centroids of the text or a polygon where the text is known to be inside. For Class A (Image-to-location) and C (Image-to-text-and-location), the locations returned by the implementation **MUST** be a Polygon.
5.	};	

341 ### 2.4.4. Data structure for return value of API function calls

342 **Table 9 – Enumeration of return codes for API function calls**

	Return code as C++ enumeration	Meaning
	enum class ReturnCode {	
1.	Success=0,	Success
2.	ConfigError=1,	Error reading configuration files
3.	RefuseInput=2,	Elective refusal to process the input
4.	VendorError=3,	Vendor-defined error
5.	NotImplemented=4	Function is not implemented by provider
6.	};	

343 **Table 10 – ReturnStatus structure**

	C++ code fragment	Meaning
	struct ReturnStatus {	
1.	TRAIT2016::ReturnCode code;	Return Code
2.	std::string info;	Optional information string
3.	// constructors	
4.	};	

3. API Specification

3.1. Image-to-location

3.1.1. Overview

This section defines an API for algorithms that can perform solely text detection. This does not reflect an operational use-case per se, but is included in this evaluation to identify capable algorithms and to support, in-principle, good detection algorithms that have poor recognition capability.

3.1.2. API

3.1.2.1. Interface

The Class A software under test must implement the interface `ImgToLocationInterface` by subclassing this class and implementing each method specified therein.

	C++ code fragment	Remarks
1.	`class ImgToLocationInterface`	
2.	`{` `public:`	
3.	`virtual ReturnStatus initialize_text_detector(` `const std::string &configuration_location);`	

4.	`virtual ReturnStatus detect_text_in_still(`
	`const Image &image,`
	`std::vector<Location> &textLocations) = 0;`	

5.	`virtual void set_gpu(uint8_t gpuNum) = 0;`	
6.	`static ClassAImplPtr getImplementation();`	Factory method to return a managed pointer to the `ImgToLocationInterface` object. This function is implemented by the submitted library and must return a managed pointer to the `ImgToLocationInterface` object.
7.	`};`	

There is one class (static) method declared in `ImgToLocationInterface`, `getImplementation()` which must also be implemented by the SDK. This method returns a shared pointer to the object of the interface type, an instantiation of the implementation class. A typical implementation of this method is also shown below as an example.

	C++ code fragment	Remarks

	`#include "trait2016NullImplClassA.h"`
	
	`using namespace TRAIT2016;`
	
	`NullImplClassA::NullImplClassA() { }`
	
	`NullImplClassA::~NullImplClassA() { }`
	
	`ClassAImplPtr`
	`ImgToLocationInterface::getImplementation()`
	`{`
	`NullImplClassA *p = new NullImplClassA();`
	`ClassAImplPtr ip(p);`
	`return (ip);`
	`}`
	
	`// Other implemented functions`	

3.1.2.2. Initialization

Before any text detection calls are made, the NIST test harness will make a call to the initialization of the function in Table 11.

Table 11 – SDK initialization

Prototype	ReturnStatus initialize_text_detector(const std::string &configuration_location);	 Input
Description	This function initializes the SDK under test. It will be called by the NIST application before any call to `detect_text_in_still()` is made.	
Input Parameters	configuration_location	A read-only directory containing any developer-supplied configuration parameters or run-time data files. The name of this directory is assigned by NIST. It is not hardwired by the provider. The names of the files in this directory are hardwired in the SDK and are unrestricted.
Return Code	Success	Success
	ConfigError	Vendor provided configuration files are not readable in the indicated location.
	VendorError	Vendor-defined failure

3.1.2.3. GPU Index Specification

For implementations using GPUs, the function of Table 12 specifies a sequential index for which GPU device to execute on. This enables the test software to orchestrate load balancing across multiple GPUs.

Table 12 – GPU index specification

Prototypes	void set_gpu (uint8_t gpuNum);	 Input
Description	This function sets the GPU device number to be used by all subsequent implementation function calls. `gpuNum` is a zero-based sequence value of which GPU device to use. 0 would mean the first detected GPU, 1 would be the second GPU, etc. If the implementation does not use GPUs, then this function call should simply do nothing.	
Input Parameters	gpuNum	Index number representing which GPU to use.

3.1.2.4. Text detection

The text detection functions of Table 13 accept input imagery and report the location(s) of zero or more lines of text, in the form of a closed polygon. NIST may evaluate on images with no text in them.

Table 13 – Text detection

Prototypes	ReturnStatus detect_text_in_still (const Image &image, std::vector<Location> &textLocations);	 Input Output
Description	This function takes, respectively, a still image and returns the locations of lines of text, if any, in the form of closed polygon(s). The output `textLocations` vector will initially be empty. It is up to the implementation to populate the vector and ensure `textStrings.size()==images.size.`	
Input Parameters	Image	A Table 5 structure
Output Parameters	textLocations	A vector of Table 8 structure
Return Code	Success	Success
	RefuseInput	Elective refusal to process the input – e.g., because quality is too poor
	VendorError	Vendor-defined failure. Failure codes must be documented and communicated to NIST with the submission of the implementation under test.

3.2. Image-to-text with provided location information

3.2.1. Overview

This section defines an API for algorithms that perform recognition given text location in an image. This is not a primary operational use-case, but is included for NIST to evaluate the relative difficulties of detection vs. recognition. The location(s) of the text will be provided to the algorithm either in the form of a line through the centroids of the text or a closed bounding box polygon around the text. Most of the text locations provided via bounding boxes contain a single line of text, but some may contain multiple lines of text. The bounding boxes aren't necessarily tight around the text.

3.2.2. API

3.2.2.1. Interface

The Class B software under test must implement the interface `ImgToTextInterface` by subclassing this class and implementing each method specified therein. See

	C++ code fragment	Remarks
1.	`class ImgToTextInterface`	
2.	`{` `public:`	
3.	`virtual ReturnStatus initialize_text_recognizer(` `const std::string &configuration_location);`	

4.	`virtual ReturnStatus recognize_text_in_still(`
	`const Image &image,`
	`const std::vector<Location> &textLocations,`
	`std::vector<std::string> &textStrings) = 0;`	

5.	`virtual void set_gpu(uint8_t gpuNum) = 0;`	
6.	`static ClassBImplPtr getImplementation();`	Factory method to return a managed pointer to the `ImgToTextInterface` object. This function is implemented by the submitted library and must return a managed pointer to the `ImgToTextInterface` object.
7.	`};`	

There is one class (static) method declared in `ImgToTextInterface`, `getImplementation()` which must also be implemented by the SDK. This method returns a shared pointer to the object of the interface type, an instantiation of the implementation class. A typical implementation of this method is also shown below as an example.

	C++ code fragment	Remarks

	`#include "trait2016NullImplClassB.h"`
	
	`using namespace TRAIT2016;`
	
	`NullImplClassB::NullImplClassB() { }`
	
	`NullImplClassB::~NullImplClassB() { }`
	
	`ClassBImplPtr`
	`ImgToTextInterface::getImplementation()`
	`{`
	`NullImplClassB *p = new NullImplClassB();`
	`ClassBImplPtr ip(p);`
	`return (ip);`
	`}`
	
	`// Other implemented functions`	

3.2.2.2. Initialization

Before any text recognition calls are made, the NIST test harness will make a call to the initialization of the function in Table 14.

Table 14 – SDK initialization

Prototype	ReturnStatus initialize_text_recognizer(const std::string &configuration_location);	 Input
Description	This function initializes the SDK under test. It will be called by the NIST application before any call to `recognize_text_in_still()`.	
Input Parameters	configuration_location	A read-only directory containing any developer-supplied configuration parameters or run-time data files. The name of this directory is assigned by NIST. It is not hardwired by the provider. The names of the files in this directory are hardwired in the SDK and are unrestricted.
Return Code	Success	Success
	ConfigError	Vendor provided configuration files are not readable in the indicated location.
	Other	Vendor-defined failure

3.2.2.3. GPU Index Specification

For implementations using GPUs, the function of Table 15 specifies a sequential index for which GPU device to execute on. This enables the test software to orchestrate load balancing across multiple GPUs.

Table 15 – GPU index specification

Prototypes	void set_gpu (uint8_t gpuNum);	 Input
Description	This function sets the GPU device number to be used by all subsequent implementation function calls. `gpuNum` is a zero-based sequence value of which GPU device to use. 0 would mean the first detected GPU, 1 would be the second GPU, etc. If the implementation does not use GPUs, then this function call should simply do nothing.	
Input Parameters	gpuNum	Index number representing which GPU to use.

3.2.2.4. Text recognition with provided location information

The text recognition functions of Table 16 accept input imagery and locations of text in the image and report zero or more lines of recognized text. NIST may provide locations where no text exists, and the implementation should handle that.

Table 16 – Text recognition

Prototypes	ReturnStatus recognize_text_in_still(const Image &image, const std::vector<Location> &textLocations, std::vector<std::string> &textStrings);	 Input Input Output
Description	This function takes a still images and K >= 1 locations of text and returns K (possibly empty) strings of text for the image. The output vector will initially be empty and it is up to the implementation to ensure that `textStrings.size()==images.size()`. `textStrings[i]` should correspond to the location information from `textLocations[i]`. If no text is recognized for a particular provided location, the implementation shall populate `textStrings[i]` with an empty string (i.e., “”). The provided location information will be in the form of a line, that is, `textLocations[i].type=Line`.	
Input Parameters	image	A Table 5 structure
	textLocations	A vector of Table 8 structure
Output Parameters	textStrings	A vector of std::string
Return Code	Success	Success
	RefuseInput	Elective refusal to process the input – e.g. because quality is too poor
	VendorError	Vendor-defined failure. Failure codes must be documented and communicated to NIST with the submission of the implementation under test.

3.3. Image-to-text-and-location

3.3.1. Overview

This section defines an API for algorithms that can perform text recognition in stills. This reflects the primary operational use-case.

3.3.2. API

3.3.2.1. Interface

The Class C software under test must implement the interface `ImgToTextAndLocInterface` by subclassing this class and implementing each method specified therein. See

	C++ code fragment	Remarks
1.	`class ImgToTextAndLocInterface`	
2.	`{` `public:`	

3.	`virtual ReturnStatus initialize_text_processor(`
	`const std::string &configuration_location,`
	`bool &useGPU);`	

4.	`virtual ReturnStatus process_text_in_still(`
	`const Image &image,`
	`std::vector<Location> &textLocations,`
	`std::vector<std::string> &textStrings) = 0;`	

5.	`virtual void set_gpu(uint8_t gpuNum) = 0;`	

6.	`virtual ReturnStatus process_urls_in_still(`
	`const Image &image,`
	`double &confidenceScore,`
	`std::vector<Location> &urlLocations,`
	`std::vector<std::string> &urlStrings);`	

7.	`static ClassCImplPtr getImplementation();`	Factory method to return a managed pointer to the `ImgToTextAndLocInterface` object. This function is implemented by the submitted library and must return a managed pointer to the `ImgToTextAndLocInterface` object.
8.	`};`	

There is one class (static) method declared in `ImgToTextAndLocInterface`, `getImplementation()` which

instantiation of the implementation class. A typical implementation of this method is also shown below as an example.

	C++ code fragment	Remarks

```
#include "trait2016NullImplClassC.h"

using namespace TRAIT2016;

NullImplClassC::NullImplClassC() { }

NullImplClassC::~NullImplClassC() { }

ClassCImplPtr
ImgToTextAndLocInterface::getImplementation()
{
        NullImplClassC *p = new NullImplClassC();
        ClassCImplPtr ip(p);
        return (ip);
}

// Other implemented functions
```

413

414 **3.3.2.2. Initialization**

415 Before any text recognition/processing calls are made, the NIST test harness will make a call to the initialization of the
416 function in Table 14.

417 **Table 17 – SDK initialization**

Prototype	ReturnStatus initialize_text_processor(const std::string &configuration_location);	 Input
Description	This function initializes the SDK under test. It will be called by the NIST application before any call to `process_text_in_still()` is made.	
Input Parameters	configuration_location	A read-only directory containing any developer-supplied configuration parameters or run-time data files. The name of this directory is assigned by NIST. It is not hardwired by the provider. The names of the files in this directory are hardwired in the SDK and are unrestricted.
Return Code	Success	Success
	ConfigError	Vendor provided configuration files are not readable in the indicated location.
	VendorError	Vendor-defined failure

418 **3.3.2.3. GPU Index Specification**

419 For implementations using GPUs, the function of Table 18 specifies a sequential index for which GPU device to execute
420 on. This enables the test software to orchestrate load balancing across multiple GPUs.

421 **Table 18 – GPU index specification**

Prototypes	void set_gpu (uint8_t gpuNum);	 Input
Description	This function sets the GPU device number to be used by all subsequent implementation function calls. `gpuNum` is a zero-based sequence value of which GPU device to use. 0 would mean the first detected GPU, 1 would be the second GPU, etc. If the implementation does not use GPUs, then this function call should simply do nothing.	
Input Parameters	gpuNum	Index number representing which GPU to use.

422 **3.3.2.4. Text processing without location information**

423 The text processing function of Table 19 accepts input imagery and report zero or more lines of text.

424 **Table 19 – Text processing**

Prototypes	ReturnStatus process_text_in_still(const Image &image, std::vector<Location> &textLocations, std::vector<std::string> &textStrings);	 Input Output Output

Description	This function takes a still image and returns strings of text and their corresponding locations found in the image. `textStrings[i]` shall correspond to the location(s) for text in `textLocations[i]`. The output vectors will initially be empty and it is up to the implementation to ensure that `textLocations.size()==textStrings.size()`. The implementation shall report the location of lines of text in the form of a closed polygon, that is, `textLocations[].type=Polygon`.	
Input Parameters	image	A Table 5 structure
Output Parameters	textLocations	A vector of Table 8 structure
	textStrings	A vector of std::string
Return Code	Success	Success
	RefuseInput	Elective refusal to process the input – e.g. because quality is too poor
	VendorError	Vendor-defined failure. Failure codes must be documented and communicated to NIST with the submission of the implementation under test.

425 **3.3.2.5. URL detection and recognition**

426 The URL processing function of Table 20 accepts input imagery and report zero or more lines of URL text along with a URL
427 detection confidence score. Implementation of this function is optional but encouraged.

428 **Table 20 – URL processing**

Prototypes	ReturnStatus process_urls_in_still(	
	const Image &image,	Input
	double &confidenceScore,	Output
	std::vector<Location> &urlLocations,	Output
	std::vector<std::string> &urlStrings);	Output
Description	This function takes a still image and returns zero or more strings of URL text and their corresponding locations found in the image, along with a URL detection confidence score on [0,1], with 0 indicating certainty that the image contains no URL text, and 1 indicating certainty that image contains URL text. The score will be used to perform threshold-based analysis of algorithm URL detection performance. `urlStrings[i]` shall correspond to the location(s) for URL text in `urlLocations[i]`. The output vectors will initially be empty and it is up to the implementation to ensure that `textLocations.size()==textStrings.size()`. The implementation shall report the location of lines of text in the form of a closed polygon, that is, `textLocations[].type=Polygon`.	
Input Parameters	image	A Table 5 structure
Output Parameters	confidenceScore	A measure of certainty that the image contains a URL. This value shall be on [0,1], with 0 indicating certainty of no URL text in image and 1 indicating certainty of the existence of URL text in image
	urlLocations	A vector of Table 8 structure
	urlStrings	A vector of std::string
Return Code	Success	Success
	RefuseInput	Elective refusal to process the input – e.g. because quality is too poor
	VendorError	Vendor-defined failure. Failure codes must be documented and communicated to NIST with the submission of the implementation under test.

429

Annex A
Submission of Implementations to the TRAIT 2016

A.1 Submission of implementations to NIST

NIST requires that all software, data and configuration files submitted by the participants be signed and encrypted. Signing is done with the participant's private key, and encryption is done with the NIST public key. The detailed commands for signing and encrypting are given here: http://www.nist.gov/itl/iad/ig/encrypt.cfm

NIST will validate all submitted materials using the participant's public key, and the authenticity of that key will be verified using the key fingerprint. This fingerprint must be submitted to NIST by writing it on the signed participation agreement.

By encrypting the submissions, we ensure privacy; by signing the submissions, we ensure authenticity (the software actually belongs to the submitter). NIST will reject any submission that is not signed and encrypted. NIST accepts no responsibility for anything that is transmitted to NIST that is not signed and encrypted with the NIST public key.

A.2 How to participate

Those wishing to participate in TRAIT 2016 testing must do all of the following, on the schedule listed in this document.

- IMPORTANT: Follow the instructions for cryptographic protection of your SDK and data here. http://www.nist.gov/itl/iad/ig/encrypt.cfm
- Send a signed and fully completed copy of the *Application to Participate in the Text Recognition Algorithm Independent Test (TRAIT) 2016*. This is available at http://www.nist.gov/itl/iad/ig/trait-2016.cfm. This must identify, and include signatures from, the Responsible Parties as defined in the application. The properly signed TRAIT 2016 Application to Participate shall be sent to NIST as a PDF.
- Provide an SDK (Software Development Kit) library which complies with the API (Application Programmer Interface) specified in this document.
    - Encrypted data and SDKs below 20MB can be emailed to NIST at trait2016@nist.gov.
    - Encrypted data and SDKS above 20MB shall be

      EITHER
        - Split into sections AFTER the encryption step. Use the unix "split" commands to make 9MB chunks, and then rename to include the filename extension need for passage through the NIST firewall.
        - `you%  split -a 3 -d -b 9000000  libTRAIT2016_enron_A_02.tgz.gpg`
        - `you%  ls -1 x??? | xargs -iQ  mv Q libTRAIT2016_enron_A_02_Q.tgz.gpg`
        - Email each part in a separate email. Upon receipt NIST will
        - `nist%  cat TRAIT2016_enron_A02_*.tgz.gpg > libTRAIT2016_enron_A_02.tgz.gpg`

      OR
        - Made available as a file.zip.gpg or file.zip.asc download from a generic http webserver[1],

      OR
        - Mailed as a file.zip.gpg or file.zip.asc on CD / DVD to NIST at this address:

TRAIT 2016 Test Liaison (A203) 100 Bureau Drive A203/Tech225/Stop 8940 NIST Gaithersburg, MD 20899-8940 USA	In cases where a courier needs a phone number, please use NIST shipping and handling on: 301 -- 975 -- 6296.

[1] NIST will not register, or establish any kind of membership, on the provided website.

A.3 Implementation validation

Registered Participants will be provided with a small validation dataset and test program available on the website.

http://www.nist.gov/itl/iad/ig/trait-2016.cfm shortly after the final evaluation plan is released.

The validation test programs shall be compiled by the provider. The output of these programs shall be submitted to NIST.

Prior to submission of the SDK and validation data, the Participant must verify that their software executes on the validation images, and produces correct similarity scores and templates.

Software submitted shall implement the TRAIT 2016 API Specification as detailed in the body of this document.

Upon receipt of the SDK and validation output, NIST will attempt to reproduce the same output by executing the SDK on the validation imagery, using a NIST computer. In the event of disagreement in the output, or other difficulties, the Participant will be notified.