SANDIA REPORT

SAND2002-0290
Unlimited Release
Printed February 2002

Performance Evaluation of the IrisScan2200 Against Four Respirator Masks

Larry J. Wright and Preston L. Terry

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

Sandia is a multiprogram laboratory operated by Sandia Corporation,
a Lockheed Martin Company, for the United States Department of
Energy under Contract DE-AC04-94AL85000.

Sandia National Laboratories

Issued by Sandia National Laboratories, operated for the United States Department of Energy by Sandia Corporation.

Printed in the United States of America. This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from
U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831

Telephone: (865)576-8401
Facsimile: (865)576-5728
E-Mail: reports@adonis.osti.gov
Online ordering: http://www.doe.gov/bridge

Available to the public from
U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Rd
Springfield, VA 22161

Telephone: (800)553-6847
Facsimile: (703)605-6900
E-Mail: orders@ntis.fedworld.gov
Online order: http://www.ntis.gov/ordering.htm

SAND2002-0290
Unlimited Release
Printed February 2002

Performance Evaluation of the IrisScan2200 Against Four Respirator Masks

Larry J. Wright and Preston L. Terry
Entry Control and Contraband Detection Department
Sandia National Laboratories
PO Box 5800
Albuquerque, NM 87185-0782

Abstract

The use of biometrics for the identification of individuals is becoming more prevalent in society and in the general government community. As the demand for these devices increases, it becomes necessary for the user community to have the facts needed to determine which device is the most appropriate for any given application. One such application is the use of biometric devices in areas where an individual may not be able to present a biometric feature that requires contact with the identifier (e.g., when dressed in anti-contamination suits or when wearing a respirator). This paper discusses a performance evaluation conducted on the IrisScan2200 from Iridian Technologies to determine if it could be used in such a role.

This page intentionally left blank.

Contents

Figures

Tables

Acronyms

DOE	Department of Energy
FRR	false reject rate
FTE	failure to enroll
GB	gigabytes
MB	megabytes
OSS	Office of Safeguards and Security
PC	personal computer
PIN	personal identification number
SNL	Sandia National Laboratories

This page intentionally left blank.

Introduction

This report describes the results of a performance evaluation to determine the ability of the IrisScan2200, an iris recognition system produced by Iridian Technologies, Inc., to verify individuals while they were wearing respirator masks.

All of the above equipment is commercially available. The Department of Energy (DOE), Office of Safeguards and Security (OSS) funded this work to determine the performance characteristic of this system and to determine the applicable use of this technology in the DOE community.

Background

The use of biometrics for the identification of individuals is becoming more prevalent in society and in the general government community. As the number and variety of these devices increase, it becomes necessary for the user community to have the facts needed to determine if biometrics are needed for use in their facility and, if so, which device is the most appropriate.

The identification of individuals takes place via two different processes: verification and recognition. ***Verification*** is defined as a one-to-one identification process whereby an individual submits a claim of identity and the biometric software then compares the live biometric scan to the stored template associated with that claim of identity. ***Recognition*** is a one-to-many identification process where the biometric software searches the entire database for a match to the submitted biometric sample. The unit evaluated in this test, the IrisScan2200, operates in the recognition mode.

Purpose

There are times when it is desirable to have a hands-free biometric available to be used when personnel are dressed in anti-contamination suits and wearing respirators. In this situation, an individual is unable to undress to use a contact biometric like a fingerprint or hand geometry device. Therefore, an alternative device is being sought.

The purpose of the test was to determine if the false rejection rate (FRR) of the IrisScan2200 changes when used in an environment where the user must look through a face mask. A previous evaluation by Sandia National Laboratories [1] determined the FRR of this system in a normal environment. This rate was determined to be 1.35%, which means that an authorized user will be falsely rejected 1.35% of the time. This evaluation was designed to determine any changes in the false reject rate while the user was wearing a respirator mask.

Four different respirator masks, all used by members of the DOE community, were selected for use in this evaluation. They were the Avon FM-12, Draeger Panorama Nova, MSA Ultra Twin, and Scott-a-Vista (**Figure 1**).

Figure 1. a) Draeger Panorama Nova, b) Scott-a-Vista, c) Avon FM-12, d) MSA Ultra Twin

System Operation

IrisScan2200 Iris Recognition System Description

The IrisScan2200 is an iris recognition device from Iridian Corporation. Iris recognition is based on the physical characteristics observable in the iris (**Figure 2**), the most prominent of which is the trabecular meshwork.

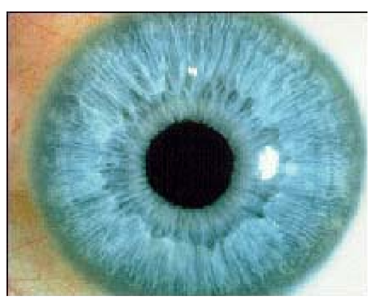

Figure 2. The Iris

This structure is the tissue that gives the appearance of dividing the iris in a radial fashion. Other visible characteristics include rings, furrows, freckles, and the corona, among others. The iris recognition technology converts these visible characteristics into a 512 byte IrisCode™ or template. The IrisCode™ is stored in hexadecimal format (**Figure 3**) in a database allowing it to be used for comparing with a live IrisCode captured during a recognition.

Figure 3. Sample IrisCode™

The following sections describe the system components, installation, and operation.

System Components

As configured for the test, the system consists of:

- an enrollment camera unit (**Figure 3**)
- a remote recognition camera unit (**Figures 4** and **5**)
- an integrated controller PC/administration workstation

The remote recognition unit and a magnetic stripe card reader are mounted on the wall in the entry alcove to the Access Control Laboratory (**Figure 5**). The controller PC, enrollment unit, and associated hardware are installed behind the wall. The remote unit camera is mounted so that it is approximately 64 inches above the floor. The camera head is constructed so that it can be rotated vertically to accommodate users of different heights.

Figure 4. IrisScan Remote and Enrollment Units

The controller PC is a PentiumIII, 650MHz, with a 5 GB hard drive, 64 MB memory, and a 10BaseT network adapter card. The system also includes the necessary software to accomplish enrollments, manage the user database, configure the system, manage the remote unit, and perform recognition determinations.

System Installation

The system was installed in an entry alcove to the Access Control Laboratory. **Figure 4** depicts the installation of the remote unit. The installation went very smoothly and no equipment defects were noted. The presence of supplier support personnel helped greatly. The remote recognition unit and magnetic stripe card reader are mounted on the wall in the entry alcove to the Access Control Laboratory (Figure 5). The controller PC, enrollment unit, and associated hardware are installed behind the wall. The remote unit camera is mounted so that it is approximately 64 inches above the floor. The camera head is constructed so that it can be rotated vertically to accommodate users of different heights.

Since the IrisScan2000 operates in a recognition mode (i.e., one-to-many), the ability to detect an imposter via the software was hindered. In an effort to determine if we received any false accepts, a separate logging program was run concurrently with the recognition software, and users were asked to run their magnetic stripe card through a reader prior to performing an access attempt.

Figure 5. Alcove Installation of the Remote Unit (left) and Closeup (right)

The system was installed with the support of vendor personnel, which made the installation much easier.

System Operation

When the user presents him/herself for verification, the system automatically detects (from a distance of about three to ten inches) that someone or something is present and starts the process to identify and capture a digital image of the iris. Once an image is captured, the system searches the database of enrolled images to determine if there is a match to a stored image. Since the iris scan unit works in the recognition mode, the only result of this comparison is an accept or reject decision. A more detailed presentation of the IrisScan technology is presented in **Appendix A**.

User Safety

Iridian's product literature states that "Iris identification uses standard video cameras ... and therefore has none of the inherent risks associated with lasers."

The literature also claims that "Iridian Technologies™ product lines … are in compliance with all applicable international illumination safety standards including, American National Standard ANSI/IESNA RP-27.1-96 and International Standard IEC 60825-1, Class 1 LED."[2]

Enrollment and Access Attempts

Generally, enrolling users is done under the supervision of a system administrator, and involves two steps:

- completing a database record for the user
- enrolling the user's biometric image to create the template.

The database record is completed by the system administrator using the software provided by the vendor. For the purpose of the evaluation and to ensure the privacy of the user, the data in each record consisted of only the user's personal identification number (PIN). Once the database entry was completed, the user was asked to present his/her biometric feature to the device for enrollment.

IrisScan

During the enrollment process, the IrisScan required three images for each iris. Both the left and right irises were enrolled for the evaluation. The IrisScan software also required the user to verify the enrollment immediately after the enrollment images were captured and processed.

To accomplish an access attempt, the user was required to look into a rectangular target on a mirrored surface built into the remote unit. If the user was too close or too far away, the system would audibly ask the user to move back or move forward. The entire access attempt took from one to several seconds. Once an access decision was made, the system would announce the result audibly.

Test Methodology

Human volunteers were used to characterize the system's performance. The following sections describe the test methodology, particularly as it involves human subjects.

The evaluation was conducted in an entry alcove to the Entry Control Laboratory in Building 821 at SNL (**Figure 5**).

Population Size, Number of Trials

For this evaluation, the target population size was 10 people. The target number of trials was 10 attempts per user on both the left and right iris for a total of 20 attempts per user for each mask.

Test Subject Recruitment

All test subjects were recruited from employees and contractors of Sandia. Since the iris system was installed in the Entry Control Laboratory in Building 821, subjects were recruited from this building by posting flyers on the entry doors and sending an e-mail request to building occupants.

The only inclusion/exclusion criterion was ready access to the Entry Control Laboratory. Recruitment of subjects followed all guidelines of the Sandia Human Studies Board.

- Participation in the study was voluntary, and subjects were free to withdraw from the study at any time without penalty.
- All test subjects received a complete description of the project, including risks (none) and benefits, the goals of the study, sponsor (funding source), and the uses of the data.
- Subjects were provided an opportunity to ask questions and were asked to sign a Consent Form indicating that they had received all information needed to make an informed decision regarding their participation in the test. All subjects received a copy of the consent form.
- There was no financial compensation for participating in the study.

Identity of test subjects in the study was treated as private. Only test project personnel were allowed access to information that ties image and performance data to particular subjects. Participants were instructed not to wear hats or sunglasses during the test. These articles shadow portions of the face and are known to decrease system performance. Participants were also requested not to wear glasses.

Test Setup

All equipment settings were left at the manufacturer's default settings. There were no attempts to change threshold settings on those systems that had that capability.

Test Procedure and Data Collection

Enrolled users were asked to verify 20 times with each mask (10 times with each iris). To determine the FRR of the system, 200 total attempts were collected using each mask for a total of 800 attempts. Since this was a proctored test, all results were manually recorded for future analysis.

Test Group Characteristics

For this evaluation, 10 volunteers were selected from the test group who were previously enrolled on the iris system and had participated in the previous evaluation. The group's characteristics were as follows:

- 9 men, 1 woman
- 5 users normally wore glasses
- all volunteers were SNL employees or contractors residing in Building 821 and were representative of both technical and administrative occupations and several ethnic groups.

Test Results

System performance was characterized in terms of the false reject rate. The false-reject error rate is the ratio of false-rejects to total attempts at verification. A false reject will be represented as FRR and is reported in this document as a percentage value.

Since the IrisScan2200 operates at a fixed threshold and no scores were generated, false reject rates could not be determined in the traditional sense. During this evaluation, there were 800 valid user attempts collected – 200 for each mask. This number included both right and left irises. The false reject rates for each mask, expressed as a percentage, are shown in **Table 1**:

Table 1. Mask False Reject Rates

Mask Type	Right Iris FRR (%)	Left Iris FRR (%)	Combined FRR (%)
Avon FM-12	2.0	4.0	3.0
Draeger Panorama Nova	12.0	8.0	10.0
MSA Ultra Twin	18.0	12.0	15.0
Scott-a-Vista	4.0	2.0	3.0

One subject accounted for 74% of the failures. This individual normally wears glasses and had problems focusing on the IrisScan target rectangle. If those scores are factored out, the test results are as shown in **Table 2**:

Table 2. Mask False Reject Rates without Failure Rates of One Individual

Mask Type	Right Iris FRR (%)	Left Iris FRR (%)	Combined FRR (%)
Avon FM-12	0.0	2.0	1.0
Draeger Panorama Nova	5.0	0.0	3.0
MSA Ultra Twin	9.0	3.0	7.0
Scott-a-Vista	0.0	0.0	0.0

Concerns

Several concerns came up during the administration of the test.

The height of the individual seemed to make a difference, especially with shorter individuals. Having to look up into the recognition unit seemed to create more glare on the mask causing the individual to have problems finding and focusing on the target rectangle.

Almost all the participants experienced problems with fogging of the mask lens. After stopping and allowing the lens to clear, individuals were able to successfully continue.

As mentioned above, one individual accounted for 74% of the failures due to an inability to focus on the target rectangle. Personnel who wear glasses with heavy correction would also need the correction applied to the lenses of their protective mask.

Summary

With the exception of one individual, the IrisScan2200, using the Avon FM-12 and Scott-a-Vista, performed as well or better than the unit did when not using a respirator mask. The Draeger mask showed only a slight deterioration of performance while the MSA Ultra Twin showed the worst performance. In general, all four masks showed acceptable performance and could be used with the IrisScan2200 in an environment where hands-free biometrics are required.

Appendix A: Description of IrisScan Technology

Today's iris recognition technology is based on the work of Dr. John Daugman of the University of Cambridge Computer Laboratory as a practical application of his research in computer vision, wavelets, and statistical pattern recognition. The information and images in this appendix are taken from his web site at http://www.cl.cam.ac.uk/users/jgd1000/.

Iris recognition leverages the unique features of the human iris to provide identification. The algorithms used in iris recognition are extremely accurate. The technology also addresses the FTE (failure to enroll) problems that lessen the effectiveness of other biometrics. The accuracy of iris recognition distinguishes it from other biometric technologies. All iris recognition technology is based on research and patents held by Dr. John Daugman.

Iris recognition is based on the physical characteristics observable in the iris (**Figure A1**), the most prominent of which is the trabecular meshwork.

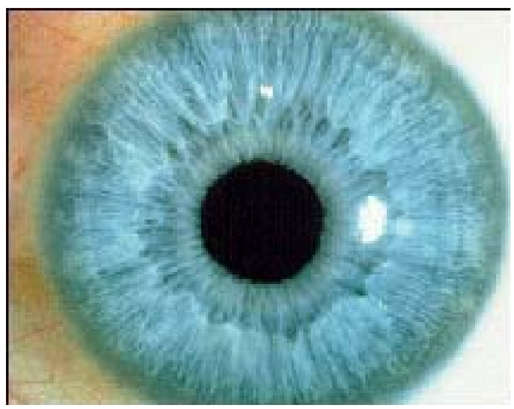

Figure A1. The Iris

This structure is the tissue that gives the appearance of dividing the iris in a radial fashion. Other visible characteristics include rings, furrows, freckles, and the corona, among others. The iris recognition technology converts these visible characteristics into a 512 byte IrisCode™ or template. The IrisCode™ is stored in hexadecimal format (**Figure A2**) in a database allowing it to be used for comparing with a live IrisCode captured during a recognition.

Figure A2. Sample IrisCode™

The quantity of information that can be gathered from the iris is tremendous. Dr. Daugman's algorithms generate a large amount of data, approximately 3 bits of data per square mm of iris. "This density of information is such that each iris can be said to have 266 unique 'spots', as opposed to 13-60 for traditional biometric technologies."[1] After allowing for the algorithm' correlative functions and for characteristics inherent to most human eyes, Dr. Daugman concludes that 173 "independent binary degrees-of-freedom" can be extracted from his algorithm, an exceptionally large number for a biometric.

The Algorithms

The first step in the algorithm is to locate the iris with a camera positioned no more than 3 feet from the eye. After the camera finds the eye, the algorithm locates the right and left outer edges of the iris (**Figure A3**). By approaching the iris in this manner, obstructions caused by the eyelids can be reduced or avoided. At the same time, the inner edge of the iris (at the pupil) is located. The lower 90° of the iris is excluded because of moisture and lighting issues.

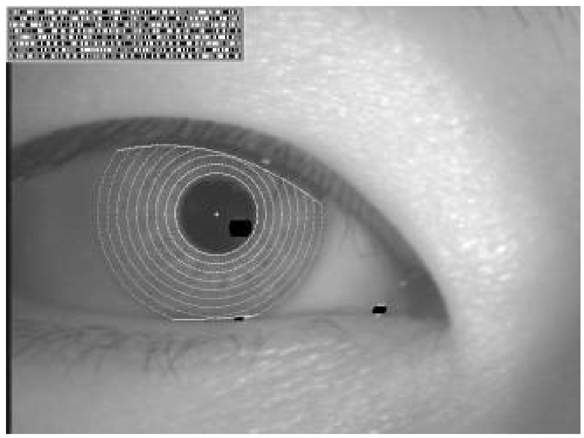

Figure A3. Locating and Mapping of the Iris

The monochrome camera used to capture the iris image uses both visible and infrared light, the latter of which is located in the 700-900nm range (the American Academy of Ophthalmology uses similar ranges in their studies of macular cysts). Upon location of the iris, as seen above, the image is filtered and mapped into hundreds of vectors (known as phasors) using a filtering technique known as 2-D Gabor wavelets. The 2-D Gabor phasor encoders can be summarized as follows. Wavelets of various sizes calculate values based on the orientation and spatial frequency of select areas, and along with the position of these areas, are used to form the IrisCode™. To avoid interference from the eyelids and reflected light, part of the top of the iris and 45° of the bottom are not used in the process (**Figure A4**). The IrisCode™ is then used for comparison during a recognition attempt and not the image of the iris itself.

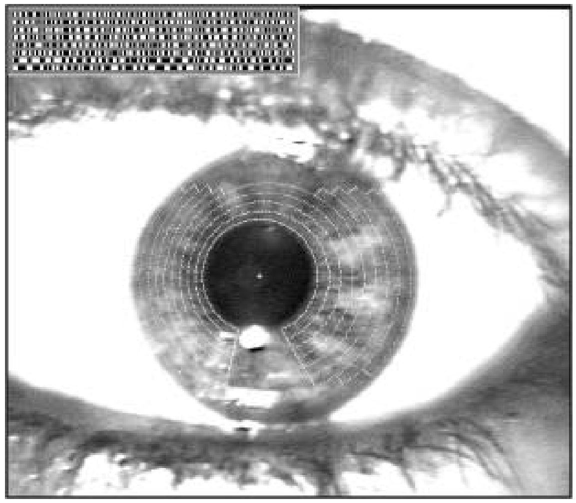

Figure A4. Parts of the Iris Not Used

“The IrisCode constructed from these complex measurements provides such a tremendous wealth of data that iris recognition offers levels of accuracy orders of magnitude higher than other biometrics. Some statistical representations of the accuracy follow:

- The odds of two different irises returning a 75% match (i.e., having a Hamming Distance of 0.25): 1 in 1016
- Equal Error Rate (the point at which the likelihood of a false accept and false reject are the same): 1 in 1.2 million
- The odds of 2 different irises returning identical IrisCodes: 1 in 1052

Other numerical derivations demonstrate the unique robustness of these algorithms. A person's right and left eyes have a statistically insignificant increase in similarity: 0.00048 on a 0.5 mean. This serves to demonstrate the hypothesis that iris shape and characteristics are phenotypic - not entirely determined by genetic structure. The algorithm can also account for occlusion (blocking) of the iris: even if 2/3 of the iris were completely obscured, accurate measure of the remaining third would result in an equal error rate of 1 in 100,000.”[2]

Iris recognition algorithms also take into account the constant movement in the eye and iris that occur in a living eye. The pupil’s expansion and contraction of the pupil in response to light causes corresponding changes in the iris. Since the recognition algorithm locates the boundaries of the iris, this movement can be accommodated. Dr. Daugman draws the analogy to a "homogenous rubber sheet" which, despite its distortion, retains certain consistent qualities. No matter what size the iris is at any given time, the same amount of data is still available to be used during an enrollment or recognition attempt. Iris recognition can also determine if a presented sample is real by the detection of papillary (pupil) changes; reflections from the cornea; detection of contact lenses atop the cornea; and use of infrared illumination to determine the state of the sample eye tissue.

Enrollment and Identification

The entire process is very brief. The iris is normally located within 1/4 second, the IrisCode generated within 1 second. Database search times are very swift, with hundreds of thousands of records analyzed per second, notwithstanding some debate as to whether a search on a truly large number of irises (tens of millions) could be conducted as quickly as is generally claimed. At this and other points, use of the algorithm actually runs into the limits of available technology. Processor speed is one bottleneck on massive searches, in addition to whatever network or hardware issues may arise. Also, the iris capture process runs into limitations of gray-scale (monochrome) imaging technology, where the darkest shades of iris coloration are difficult to distinguish from the pupil. The algorithm's robustness actually allows for significant variations in image quality. The same iris may, at different times, produce IrisCodes which vary by as much as 25% (0.25 Hamming distance from zero); this may sound like a fatal flaw, but the odds of a randomly selected IrisCode coming within even 10% of this number are exceptionally small.

References for Appendix A:

[1] http://www.cl.cam.ac.uk/users/jgd1000/

[2] http://www.iris-scan.com/iris_technology.htm

References

1. Larry J. Wright, Preston L. Terry, Sacksery Chanthery, *Performance Evaluation of Biometric Identification Devices (HandKeyII, IrisScan2200, and SpeakEZ)*, pending publication, Sandia National Laboratories
2. Iridian Technology's World Wide Web site, http://www.iriscan.com

Distribution:

1	S. Yonkoff for D. Toms Policy Integration and Technical Support, SO-13 U.S. Department of Energy Washington, DC 20585	
1	C. Pocratsky Planning and Technology Development, SO-212.4 U.S. Department of Energy Washington, DC 20585	
12	MS 0782	L. J. Wright (5848)
1	MS 0769	D. S. Miyoshi (5800)
2	MS 0899	Technical Library (9616)
1	MS 9018	Central Technical Files (8945-1)
3	MS 0782	5800 Library
1	MS 0612	Review and Approval Desk (9612) For DOE/OSTI