

Final Report (Spring 2008)

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Proposal Title: An Iris and Retina Multimodal Biometric System

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Summary

The goal of the project was to conduct a feasibility study for integration of two biometric systems, namely Iris and Retina Scans. Furthermore, the potential pros and cons of fusing the two modalities were to be identified. Research questions that we were seeking an answer for included the following:

1. To what extent can adding one modality improve the overall performance of the system?
2. Will it be better to fuse the results at the feature level or decision level?
3. Is the target application limited to confidential, top secret, high security areas only or it can be extended to public and/or commercial environments?

Findings

- i) The full fusion of identification codes of Iris and Retina Scans remarkably improves the FAR and FRR.
- ii) The Iris and Retina Scans provide complementary information, rendering no correlation between the two scans.
- iii) Iris spoofing can be prevented in almost all cases by integrating the two scans.
- iv) The fusion of the scans at the feature-level would render a better FAR than the fusion at the decision level.
- v) The required distance for the subject of an integrated system is 2 to 3 ft. With advances in imaging technology, one can boost the required distance to 10 feet or beyond, making the device suitable for a covert operation.

Deliverable

A conference paper has been accepted and is scheduled to be published and presented at The 2008 International Conference on Image Processing, Computer Vision, and Pattern Recognition (IPCV'08) .

A journal paper has been accepted by the International Journal of Security and Networks and is scheduled to appear in late 2008, Vol 3, No. 4.

Project Abstract and Scope:

The following project involves research into a combined iris and retina scanner. The scanner is to be used for security purposes in confidential, top secret, high security areas as well as for large industrial and commercial purposes. The scanner itself works just like a normal iris and retina scanner that, in theory, would scan both the iris and the retina. While the scanning time would last slightly longer than that of a normal iris or retina scanner, simply because there is more to scan, the safety benefits that come with it far outweigh these slight disadvantages.

This report will summarize the current work that has been done in the technology of iris and retina scanning including an attempt to fuse the technologies, and what would the parameters of a fully combined iris and retina scanner look like.

Background

The two biometrics that are being observed are the iris and the retina. Both the iris and the retina are randomized at birth, and it is said that no two people can have any more than 80% of the same number of bits in an iris or retina “keycode”.

Iris Scanner

The technology regarding iris scanners have gone well enough to have reached portable status. Many different companies have been making and selling iris scanners, most of them in the past year. A few companies that have been working on iris scanners are XVista, Jiristech, and Panasonic. XVista is working on a portable iris scanner. XVista’s scanner is reported to have a false match odds at 1 in 7 billion and can hold up

to 250,000 identifications on a 256MB card. The Jiristech Iris Scanner is built more for personal security, and can pick up your eye signature in less than a second. Panasonic is building a walkthrough iris scanner that can pick up one's eye signature in two seconds. They are building it for industrial purposes to speed up and increase security.

What's more impressive was the development of what is considered to be the most accurate code for an iris scanner in existence called IrisCode. IrisCode is developed by John Daugman, and with his code tested using 200-billion cross-comparisons, so far has yet to have a single false match or false non-match amongst those. Despite these amazing developments in iris recognition technology, fingerprint recognition is still much more accepted, despite it not being as accurate as the iris technology. For example, monozygotic twins have the same fingerprints, but they do not share the same iris patterns.

The latest products that have recently been released from Iritech, a company in Seoul, Korea. Their latest iris identification system involved almost no illumination and created a scan of both eyes. The system uses multi-frame iris images, (and as a result, more information) to determine if the iris is living or not. They also hold an Iriscamm product which includes a fully integrated camera system designed to scan a user's iris. This particular database contained 1200 pairs of iris images with a variety of image qualities, including blurry, contact lensed, and occluded iris images, with the result of a zero false acceptance and false rejection rate. Under these conditions, the crossover comparisons of irises under ideal conditions may have increased beyond the Daugman code of 1:131,000.

Retina Scanner

Retina scanners have been around earlier, but there are fewer of them than there are iris scanners. The primary reason for this is because the retina scanners require that a person be in a much closer distance from the scanner than the iris one, many times to the point where it is uncomfortable. A digital security corporation called eEye is the most recent manufacturer of a retina scan. The occurrence of false negatives is even lower than that of John Daugman's IrisCode. However, while the iris scan requires a person to be up to a few meters away, the retina scan requires a person to nearly be nose-to-nose with a machine in order for the scan to work.

Iris/Retinal Scanner

There is only one announced and manufactured scanner that fuses the iris and retinal recognitions together. Retica Inc. developed the Cyclops in 2006, which is a retinal scanner which also uses some of the iris patterns to create its own set of code. It is the first scanner that can both identify a person with their retinas and irises, and would be the best candidate at the moment that would be able to find a correlation between the two. The fusion of the iris and retinal identifications has created the best false match and false non-match odds of any other biometric security identifier in the industry. It can capture the biometric patterns of both the iris and the retina at distances up to one meter.



Figure 1. Diagram of the Multi-Modal Cyclops Technology (Courtesy: Retica Systems Inc.)

However, the Cyclops is a poor fusion of both the iris and the retina scanner. This does not mean that the Cyclops is not unsafe by any means. However, using only a few degrees of freedom from the iris combined with a retina scanner results in just a slightly more advanced iris scanner, that after some calculations of the degrees of freedom turned out to only have a cross-over comparison that is less than three times better than that of a retina scanner.

Results

Research shows that there is no true iris/retina scanner that is available or has been developed. With the small amount of information that is stored in an iris and retina scanner, combining the two would amount to a small 344 bytes of information per code that is stored. This does not count any information on the person itself, like gender, ethnicity, etc. which could even out the number of bytes for the administrator of the scanner.

Iris Scanner Code (256 bytes)	Retina Scanner Code (88 bytes)
Total (344 bytes)	

Table 1. Full fusion identification code of an iris/retina scanner.

The crossover comparison of a true combined iris/retina scanner using these input parameters for the matching is over 1:1,300,000,000,000. Table 2 shows the approximate crossover comparisons of all other known biometrics. A crossover figure determines the point in which the odds of getting a match when the subject does not match equal that of not getting a match when the subject does match.

Biometric	Crossover	Expected FAs and FRs (Per 1,000,000 Subjects)
Iris/Retina Scanner (Full Integration)	~1:1,300,000,000,000	Approx. 0.00003% chance of 1
Retina Scanner	1:10,000,000	Approx. 20% chance of 1
Iris Scanner	1:131,000	18
Cyclops	~1:25,000,000	Approx. 7% chance of 1
Face Recognition	1:500	4,000
Signature	1:20	100,000

Table 2. Biometric crossover comparisons by biometric.

Note that in the table that the crossover rate is when the false acceptance rate equals to that of the false rejection rate. Said biometrics in the bottom of this rate are tried and are considered secure, but mainly because the false reject rate is increased in order to lower the chances a false accept rate, presumably making the biometric more secure, but could cause slight inconvenience.

As stated earlier, there are two different kinds of algorithms for an iris biometric. One code takes only the image of an iris, which results in easy spoofing by simply placing a high resolution of another person's iris to the scanner. This is called a "static" iris scanner. The other algorithms determine if the iris is living or not by either checking the iris' response time or taking multiple images of the iris to check if its pupil is responding to any illumination. This is called a "dynamic" iris scanner, and is more common in today's technology.

However, with a combined iris and retina scanner, the need to check a living iris is no longer necessary except under extreme cases. For 99.9998% of the general population, the scanner will only have to check if the corresponding iris has a retina attached to it. A person's retinal blood vessels are given to them at birth and immediately disappear when they die. This helps both prevent retina and iris spoofing. The only

exception to this rule would be if the user had a rare disease called aniridia, which causes the person to have no iris and at times, no retina.

While the retina scanner has a false accept rate of near zero, there are a few ways that are currently being tried by research groups to see if a retina scanner can be spoofed. While some sources do claim that iris and retina scanners cannot be spoofed, recent research has surfaced that there is a possibility, albeit the chances of spoofing such a scanner would be extremely difficult for even the best of spoofers. Tinted contact lenses are the most common theory upon spoofing a retina scanner. The contact lenses could incorrectly identify the retina vessels of a person most closely with another person, or not find a match in the database for the said pattern.

Another issue with spoofing with iris/retina scanners is that 1 in 75,000 people have aniridia, a rare disease that leaves the person with no iris or retina. These people cannot be properly scanned to confirm identification with an iris or retinal scanner. This would cause problems mostly with enrollment for the scanner.

While spoofing an iris or retina scanner is extremely difficult, there seem to be many circumstances that would cause a genuine identification to be denied access due to a false non-match. In other words, while the chance of a false match, even with attempted spoofing, is extremely low, the chance of a false non-match due to particular circumstances is fairly high.

There are two different ways that we can integrate both the iris and retina systems. The first involves an integration at only the decision level. The second involves a deeper integration at the feature level.

Both the iris and retina scanner require that the iris and the retina must be isolated from the rest of the eye first. To do this, the whites of the eyes, the eyelids, and the eye itself must be eliminated. From there, the blood vessel and iris patterns are represented and the vessel and patterns are then translated into an ID code. When another ID code is translated, it is met up against every other ID code in the database. If the threshold score is met, it is identified as matching with the database.

Using a decision-level integration system, the ID codes of the iris and retina scan act as two separate entities. Isolation and representation are acted separately for each module. The two codes are then met in the matching level with an AND gate. If the iris retina score is met and the retina score is met, then the identification is confirmed. Using a feature-level integration system, the ID codes of the iris and retina are combined into one code during the representation stage of the scanner.

The crossover comparisons for both of these integration systems are the same. The sole difference is based on preference. Integrating them at the feature level will require additional code, but will result in a more convenient 344-byte passcode for the system rather than simply placing an AND over the iris and retina decisions. Integration at the decision level could be done now by placing an iris and a retina scanner in the same checkpoint station, but we are looking for a module that is able to do this at once, instead of doing them separately, leaving the user to have to be scanned twice. The additional scan gives a greater chance of human error during the screening process, which would result in a greater chance of false accepts and false rejects.

Deliverables

During the ISC West conference, we were able to get further research on the latest in iris technology, and we were able to incorporate their latest research into our findings. The most mentioned of the findings was that the latest iris scanners do not even need illumination to work. However, retina scanners still require illumination, and thus in our combined scanner integration, we would still need such a light for the scanner, but it might not be necessary to use it for the scanning of the iris. The iris scanning technology allows even blurred images of the iris to be used.

We have finished one conference paper and one journal paper . They both have been accepted, revised and scheduled to appear in 2008.

Future Work

After finding all the parameters that are what, in theory, would create a combined iris/retina scanner, the next step would be implementation of the theory by creating an actual iris/retina scanner. Further research can also be conducted regarding the parameters of this scanner, as well as what impact such a scanner would have in the world of security and criminology.

With more research on a prototype, we would be able to collect enough preliminary results to write a major proposals to one of the funding agencies such as the National Science Foundation and the Department of Homeland Security. Some of the pertinent research programs are presented in the table below.

Funding Agencies

Name	Agency	Description
Software for Real-World Systems (SRS)	NSF	How can software for real-world systems be designed, built, and analyzed in elegant and powerful new ways?
Expeditions in Computing	NSF-CISE	Research for computing-related projects at levels of up to \$2,000,000 a year.
University-Industry Cooperative Research Programs in the Mathematical Sciences (UICRP)	NSF	The Division of Mathematical Sciences (DMS) supports this relationship through the university-industry postdoctoral research fellowships, university-industry senior research fellowships, industry-based graduate research assistantships, and industry-based graduate cooperative fellowships described in this solicitation.
Homeland Security Advanced Research Project Agency (HSARPA)	DHS	HSARPA engages industry, academia, government, and other sectors in innovative research and development, rapid prototyping, and technology transfer to meet operational needs.
Defense Advanced Research Project Agency (DARPA)	DOD	The Defense Advanced Research Projects Agency (DARPA) is the central research and development organization for the Department of Defense (DoD). It manages and directs selected basic and applied research and development projects for DoD, and pursues research and technology where risk and payoff are both very high and where success may provide dramatic advances for traditional military roles and missions.
Retina Research Foundation Research Awards	RRF	For further study of scanning of the retina/iris.

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