10.1117/2.1200904.1595

Toward the next generation of iris biometrics science

Kevin Bowyer, Patrick Flynn, Karen Hollingsworth, Sarah Baker, and Sarah Ring

New eye-recognition research could result in more user-friendly and accurate technology.

Iris biometrics involves using the pattern of texture in the iris, the colored region of the eye surrounding the pupil, to verify a person's identity. The field originated in the work of John Daugman,[1,2] and, in recent years, heightened global and domestic security concerns have lead to an increased interest in iris biometric technology in academia, industry, and government.[3]

The field promises highly accurate identity verification, but a more flexible user interface is required. However, this could lead to less well-controlled image acquisition, so there is also a need for new techniques to handle a broader range of image quality. To this end, we have been supporting the US Government's Iris Challenge Evaluation programs[4] and the current Multiple Biometric Grand Challenge program,[5] as well as conducting our own basic research on iris biometrics.[6–8]

Many factors complicate the use of iris biometrics, such as differences in pupil dilation, the presence of contact lenses, and the eye's natural aging. Figure 1 shows an example of the type of image used.

Current systems largely ignore differences in pupil dilation. They also assume that the natural aging of the eye has no effect on accuracy. Commercial technology can handle some problems that arise with contact lenses, for example, but our research suggests that there are more common, subtle, and smaller effects that are currently ignored.

Iris biometrics works best when the pupil is not strongly dilated, and when the degree of dilation is similar in the image used to enroll a person in the system and the image used for verification. The conventional approach ignores differences in pupil dilation and simply converts a region from the iris image into a standard size, and then creates a corresponding binary 'iris code' based on the texture pattern. In current systems of this type, pupil dilation information is discarded.

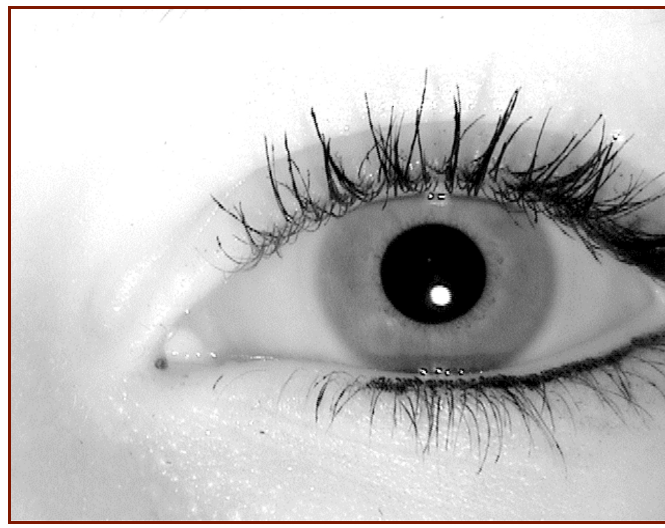

Figure 1. *Example iris biometrics image. The eyelids occlude the upper and lower parts of the iris. A shadow is cast on the lowest visible portion, and a specular reflection is seen at the top center of the visible portion. All of these factors complicate iris image analysis.*

We have demonstrated that differences in pupil dilation can degrade recognition accuracy.[7] It is perhaps not surprising that large differences in pupil dilation might increase the chance of a false-reject decision, when the system incorrectly reports that an iris does not match the enrollment version. However, our work suggests that very large pupil dilations can also increase the chances of a false match because the system incorrectly matches an iris to a different one.

One way around this problem is to keep track of the degree of pupil dilation as additional information to be stored with the iris code. Later, when iris codes are matched, differences in dilation could be factored into the reliability of the match.

The Wikipedia entry for iris recognition repeats an often-made claim: "a key advantage of iris recognition is its stability, or template longevity as, barring trauma, a single enrollment can last a lifetime".[9] Our lab has been collecting

Continued on next page

Figure 2. *Example iris image with a contact lens. This is the same eye as shown in Figure 1, but here the iris is occluded by a cosmetic contact lens.*

iris image data since 2004, and we have been exploring this statement experimentally by using images of the same iris acquired up to four years apart.

Our results show that there is a small increase in the false-reject rate in the four years between the enrollment and recognition images, compared to images taken only a few months apart.[6] But these results contradict the conventional wisdom of the iris biometrics community, and so we anticipate that our results will need to be replicated in larger studies—and by other research groups—before the time-lapse effect is accepted. If this is agreed, one approach to tackle the problem would be to establish time-related re-enrollment guidelines.

Cosmetic contact lenses obviously cause problems because their purpose is to give the iris different color and texture patterns. A person wearing cosmetic contact lenses will not be recognized as they were when they were enrolled, as a comparison of Figure 1 and Figure 2 demonstrates.

Today's iris biometrics systems are able to recognize, to some extent, when people are wearing cosmetic contact lenses. However, our work suggests that while cosmetic lenses are the bigger problem, people who wear regular contact lenses will also experience a small increase in false-reject decisions. We are therefore trying to automatically detect the smaller image artifacts that occur when normal contact lenses are worn.

There are powerful incentives, both from privacy motivations and national security concerns, to develop powerful iris biometrics technologies. US Government programs that will make large iris image and video databases available to researchers will almost certainly lead to an increase in development. This, and our future work, will contribute to a more widespread understanding of iris biometrics technology, and to new technical approaches that should result in more user-friendly technology that maintains a high degree of accuracy.

This work is supported by the Intelligence Advanced Research Projects Activity, the Technical Support Working Group under US Army contract W91CRB-08-C-0093, and by the Central Intelligence Agency and the National Science Foundation under grant CNS 013083. The opinions, findings, conclusions or recommendations expressed are those of the authors and do not necessarily reflect the views of our sponsors.

Author Information

Kevin Bowyer, Patrick Flynn, Karen Hollingsworth, Sarah Baker, and Sarah Ring
Department of Computer Science and Engineering
University of Notre Dame
Notre Dame, IN
http://www.cse.nd.edu/~kwb/
http://www.nd.edu/~flynn/

Kevin Bowyer is the Schubmehl-Prein professor and chair of the Department of Computer Science and Engineering at the University of Notre Dame. He is a past editor-in-chief of the Institute of Electrical and Electronics Engineers (IEEE) Transactions on Pattern Analysis and Machine Intelligence journal, and an IEEE Fellow.

Patrick Flynn is a professor of computer science and engineering and concurrent professor of electrical engineering at the University of Notre Dame. His research interests include computer vision, biometrics, and image processing. He is also an associate editor of IEEE Transactions on Information Forensics and Security.

Karen Hollingsworth is a PhD candidate in the Department of Computer Science and Engineering at the University of Notre Dame.

Sarah Baker is a PhD candidate in the Department of Computer Science and Engineering at the University of Notre Dame.

Continued on next page

10.1117/2.1200904.1595 Page 3/3

Sarah Ring is a graduating senior in the Department of Computer Science and Engineering at the University of Notre Dame.

References

1. John G. Daugman, *Biometric personal identification system based on iris analysis*, **U.S. patent number 5291560**, Mar 1 1994.
2. John G. Daugman, *High confidence visual recognition of persons by a test of statistical independence*, **IEEE Trans. on Patt. Anal. and Mach. Intelligence 15** (11), pp. 1148–1161, Nov, 1993. doi:10.1109/34.244676
3. Kevin W. Bowyer, Karen Hollingsworth, and Patrick J. Flynn, *Image understanding for iris biometrics: a survey*, **Comp. Vis. and Im. Understanding 110** (2), pp. 281–307, May 2008. doi:10.1016/j.cviu.2007.08.005
4. Iris Challenge Evaluation, http://iris.nist.gov/ICE/
5. Multiple Biometric Grand Challenge, http://face.nist.gov/mbgc/
6. Sarah Baker, Kevin W. Bowyer, and Patrick J. Flynn, *Empirical evidence for correct iris match score degradation with increased time lapse between gallery and probe images*, **Int. Conf. on Biometrics**, June 2009. to appear
7. Karen Hollingsworth, Kevin W. Bowyer, and Patrick J. Flynn, *Pupil dilation degrades iris biometric performance*, **Comp.Vis. and Im. Understanding 113** (1), pp. 150–157, January 2009. doi:10.1016/j.cviu.2008.08.001
8. Sarah Ring and Kevin W. Bowyer, *Detection of iris texture distortions by analyzing iris code matching results*, **Biometrics: Theory, Appl. and Systems**, September 2008. Washington, DC, doi:10.1109/BTAS.2008.4699386
9. *Iris recognition*, Wikipedia, http://en.wikipedia.org/wiki/Iris_recognition, accessed February 18, 2009