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HOUSE ARMED SERVICES COMMITTEE
TACTICAL AIR AND LAND FORCES SUBCOMMITTEE
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STATEMENT OF

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PROFESSOR, ELECTRICAL ENGINEERING DEPARTMENT
UNITED STATES NAVAL ACADEMY

AND

ENS BRADFORD L. BONNEY
UNITED STATES NAVY

BEFORE THE

TACTICAL AIR AND LAND FORCES SUBCOMMITTEE

AND THE

PROJECTION FORCES SUBCOMMITTEE

OF THE

HOUSE ARMED SERVICES COMMITTEE

ON

SMALL BUSINESS TECHNOLOGIES

JUNE 29, 2005

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Mr. Chairman, distinguished members of the Subcommittee, thank you for this opportunity to appear before you to discuss research activities in biometric technologies. These technologies have significant applications to the Department of Defense.

The research that we will discuss was performed through the Trident Scholar Program at the United States Naval Academy. This program was instituted in 1963 to provide an opportunity for exceptional students to perform research during their senior year. Midshipmen are selected to participate in this program based on assessments of written and oral presentations of their proposed research projects. Each Trident Scholar has one or more Naval Academy faculty advisors who serve as research mentors; additional mentors may also come from neighboring laboratories or universities.

ENS Bonney chose the area of iris recognition for his research project. His faculty mentors were Professor Delores Etter and Assistant Professor Robert Ives. In addition, he completed an internship the summer before his senior year at the National Security Agency, working in their biometrics program. During his senior year he continued his interactions with the National Security Agency.

The goal of this Trident Scholar research was to isolate the iris in a non-orthogonal, digital image of the human eye. A non-orthogonal iris image is an image where the eye is not looking directly at the camera. The iris is the round, pigmented tissue that lies behind the cornea. The patterns within the iris are unique to every individual; the left eye is unique from the right eye, and even identical twins have different iris patterns. Because every iris is unique, it can thus distinguish one individual from another. Iris patterns, unlike facial features used for facial recognition, do not change over time. The iris and its uniquely individual pattern are formed before birth and remain stable throughout an individual's lifetime.

All commercial iris recognition systems currently assume that captured iris images are normal, or orthogonal, to the imaging devices, and therefore search for circular patterns in the image. Off-angle, or non-orthogonal, images of irises cannot currently be used for identification because the iris appears elliptical; commercial algorithms cannot isolate an elliptical iris in order to start the identification process. This research expanded the functionality of iris recognition technology by developing a set of new algorithms to isolate a non-orthogonal iris in a digital image.

In practice, the iris pattern must be extracted from the image prior to analysis. The pattern of an iris, once captured by an infrared camera, can be analyzed, and the resulting features can be used to quantitatively and positively distinguish one eye from another. Commercial systems today utilize the patented Daugman's algorithm to detect the iris pattern using circular edge detection. As an iris image is rotated away from the normal to the imaging device, these systems develop complications in isolating the iris pattern. They are unable to successfully locate the iris pattern in order to proceed to recognition and matching. Numerous algorithms have been proposed for iris recognition; however, all of these algorithms assume that a circular iris pattern has been successfully extracted from an image.

The process for biometric recognition using the iris can be described as a series of steps that make up an architectural framework. This framework for recognition can be divided into five subcomponents, each with its own set of algorithms governing the tasks required of it. These subcomponents are:

1) *Image Preprocessing*. The first step is to determine the location of the pupil. Then, image adjustments are made for illumination, scale and rotation variations.
2) *Iris Detection*. This stage involves locating the outer edge of the iris and separating it from the remaining portions of the eye. The data representing the iris is called the iris pattern.
3) *Iris Code Generation*. Here, templates (sometimes referred to as the iris code) that will be stored in the database for authorized individuals are created. Additionally, the iris code that will be tested against the database for identification/verification is created.
4) *Comparison*. This stage performs identification/verification by comparing the new test code of the presented iris to the iris codes that have been stored in a database. This stage computes the differences between the test iris code and the stored templates.
5) *Decision*. As the final stage in the iris identification process, a decision is made based on comparisons performed in the preceding stage. Typically, a system will return either a match or will indicate that there is no match in the data base.

This research focuses on the first two of the five "plug-and-play" steps for biometric identification in the architectural framework described above. The iris detection stage is critical to the successful completion of recognition. It is the detection stage that previously relied upon a cooperative user in order to force a circular iris in the digital image. As a direct result of this research, circular patterns are no longer a prerequisite for iris segmentation. The following three stages of the identification process are being researched next year by Midshipman First Class Ruth Gaunt at the United States Naval Academy in conjunction with the Trident Scholar Program.

This project entailed the utilization of MATLAB, a computer language, to develop algorithms that analyzed digital images of a subject's eye in order to extract the iris pattern using variable elliptical boundaries. Currently, an individual needs to approach an iris scanner, pause and allow the scanner (a digital camera) to capture the image, and then make the identification. By requiring a cooperative user, the imaging device ensures that the iris image will be circular. The ability to assume a circular iris pattern simplifies the iris localization algorithms, allowing the algorithms to use circular edge detection. The newly written algorithms no longer require circular iris patterns for the successful extraction of the iris pattern. Instead, an iris pattern is removed from the image even if the iris is imaged at an angle that is not normal to the sensor.

Three possible applications for using a non-orthogonal iris image for identification will now be discussed: (1) the expanded operability, functionality, and robustness of current commercial systems, (2) the use of non-orthogonal iris capture and segmentation for partial iris pattern recognition, and (3) the ability for covert personal identification. As the iris is rotated away from the normal when captured by an imaging device, the pattern becomes elliptical and the edge detection algorithms employed by current commercial systems rejects the image for iris extraction. In order to improve the robustness of the system and, more importantly, decrease the amount of user cooperation required, segmentation and matching algorithms that do not require circular iris patterns should be developed. This added functionality will increase the freedom of users and their interactions with biometric systems.

Secondly, by developing algorithms that will successfully process partial iris patterns due to the elliptically shaped nature of a rotated iris, recognition of individuals who are not pausing to interact with the biometric system are possible. For instance, individuals may have to pass through a portal in an airport security line. That portal could collect and process the individuals' iris patterns for identification. While each person knows that their irises are being collected for identification, they do not have to make a conscious effort to cooperate with the camera.

Finally, the use of biometrics for covert identification as opposed to more intrusive forms of authentication faces many technical challenges such as inconsistent viewing angles, varying distances from the detector, and subjects that do not remain stationary. Specifically, subjects do not know they are being targeted for identification. As a result, there is no user cooperation between a subject and a biometric system. With advanced algorithms able to process elliptical iris patterns, the beginning steps for covert surveillance by means of iris recognition are formed. The follow-on research, to be continued at the Naval Academy next year, is expected to provide the remaining components for an initial system that will allow for non-orthogonal iris recognition.

The United States Naval Academy biometrics laboratory iris database was used for algorithm testing. There were 236 non-orthogonal iris images used. The algorithms developed to segment the non-orthogonal iris images were successful for 66% of the images tested. Of the same 236 images tested, none of them could be successfully segmented using current commercial systems. These algorithms provide a starting point for future research in the field of non-ideal, non-orthogonal iris segmentation and recognition. Two-thirds of the images tested that previously could not be identified by commercial systems can now be successfully segmented in preparation for positive personal identification. The recognition phase of the research will be completed next year.

Biographies:

Delores Etter currently holds the Office of Naval Research Distinguished Chair in Science and Technology, in addition to her faculty position in the Electrical Engineering Department at the United States Naval Academy. Dr. Etter joined the Naval Academy in August 2001 after completing three years as the Deputy Under Secretary of Defense for Science and Technology. Before that, she was a faculty member at the University of Colorado, Boulder, and at the University of New Mexico. Dr. Etter is a member of the National Science Board, the Defense Science Board, and the National Academy of Engineering.

Bradford Bonney is an Ensign in the United States Navy. He graduated from the United States Naval Academy in 2005, earning a Bachelors of Science degree in Electrical Engineering and a minor in the Japanese language. He spent most of his senior year performing independent research on iris recognition as a Trident Scholar. His research investigated the problem of segmenting the iris from a non-ideal, non-orthogonal digital image of the eye. He will pursue a Master's Degree at Stanford University in the fall. After completion of his studies at Stanford University, ENS Bonney will attend the Naval Nuclear Power School in Charleston, SC that will begin his career as a nuclear submarine officer.