CANDIDATE'S STATEMENT

Eliza Yingzi Du

My declared area of excellence is research/scholarship. My research interests are in biometrics, digital image processing, pattern recognition, and their applications. While in rank, I have published (including accepted) 49 peer-reviewed research papers (12 journal articles/4 book chapters/31 international conference papers/2 national conference papers), and 10 patent applications (all as the primary inventor). I am the first author or correspondent author for most of these publications (40 out of 49), and most of my publications are with my students (36 out of 49). I have been invited to give 18 seminars/presentations in international, national, regional, and campus level conferences/meetings. Overall, I have received $XXX external grants ($XXX as sole PI, and $ XXX research expenditure as Co-PI), $ XXX internal grants (all as PI), and $ XXX equipment donations (as PI). Passive Identification Technology (PIT) was formed by VAI, IU, and IURTC to develop and commercialize our non-cooperative iris recognition system. In the past five years, I have graduated four master thesis students and one Ph.D. student (co-advisor). I am honored to be a recipient of the prestigious Office of Naval Research (ONR) Young Investigator Award in 2007, the IUPUI Prestigious External Award Recognition in 2008, and Best Paper Award (with my students) by IEEE Workshop on Computational Intelligence in Biometrics: Theory, Algorithms, and Applications in 2009. In addition, I was honored to be interviewed by *Science Magazine* for my view of iris recognition in the presence of disease.

I am an enthusiastic educator with experience at the undergraduate level and graduate level. I work hard to provide a positive, trusting, and encouraging learning environment to ensure effective teaching. Furthermore, I design hands-on projects for students to both learn and practice theories, and to learn how to design. In addition to teaching both graduate and undergraduate courses, I have served as a mentor for several graduate and many undergraduate students (including several minority students). Moreover, I have connected my research with my teaching and developed the new course named Biometrics, which is well received among students. Overall, I have received very positive evaluations from the students. Both my department teaching reviewers and Faculty Colloquium Excellence in Teaching (FACET) reviewer are very satisfied with my teaching performance. I am honored to be a recipient of the Trustee Teaching Award in 2009, and IUPUI Supervisor of the Year Recognition Award in 2009. In addition, I have published two peer-refereed journal articles and one international conference paper in teaching. Currently, I have two proposals pending. If funded, it will help my department to promote minority students in pursuing electrical engineering degrees.

As a junior faculty, I have been playing an active role on committees that serve the department and school in improving curriculum development, graduate student recruiting and development, school research improvement, school senate, and the dean search. In addition, I have been very active in serving my professional communities. During these five years, I have established the biometrics and pattern recognition laboratory. This has become one of the showcase labs in our department/school and is used to support recruiting, research, local industry relationships, and other missions. The lab has been highly praised by the Purdue President Dr. Córdova during her visit with Purdue Trustee members at IUPUI in 2007.

Overall, I am on track for promotion and tenure. In the future, I will continue working hard to be productive in research, to be successful in teaching, and to be active in service. I will provide more of my support to the campus wide Research, International, Service, and Experience learning (RISE) initiative.

RESEARCH/SCHOLARSHIP: AREA OF EXCELLENCE

My research background is in biometrics, image processing, and pattern recognition. In the biometrics area, my students and I are working on following important issues: iris image quality, non-cooperative iris recognition, sclera recognition, and cancelable biometrics.

Over the past decade, many researchers have worked in the area of iris recognition and have proposed several interesting algorithms and methods. Currently, iris recognition systems work well with frontal iris images from cooperative users. Non-ideal iris images are still challenging for iris recognition and can significantly affect the accuracy of iris recognition systems for two reasons: 1) they cannot be properly preprocessed by the system; and/or 2) they have poor image quality. People have begun to work on non-cooperative and non-ideal iris recognition. However, many traditional recognition systems have been deployed and used in various locations like airports, military bases, law enforcement facilities, etc. It will be expensive to replace all these systems. We proposed a method that can help transform traditional iris recognition systems to work in non-ideal situations. This method does not change the core parts of the traditional systems, but adds four additional software modules: the Quality Filter Module, the Segmentation Evaluation Module, the Quality Measure Module, and the Score Fusion Module. The proposed method can automatically eliminate poor quality images, images with poor segmentation results, and images without sufficient feature information. The method predicts the recognition confidence by considering both the image quality and the segmentation accuracy. The experimental results demonstrate the effectiveness of this method. This project was sponsored by ONR, the National Institute of Justice (NIJ), and IUPUI. This research has resulted in several journal articles (including two IEEE Transaction papers), two patents, and one Best paper award from an IEEE conference. This project was selected as one of three showcase biometric projects ever sponsored by NIJ in Dr. William Ford's (Division Director, Information and Sensor Technology Division, NIJ) presentation in the Biometric Consortium Conference in Sept. 2009.

However, these quality modules could not enable iris recognition under non-cooperative situations. Performing non-cooperative iris recognition is important for a number of tasks, such as video surveillance and watchlist monitoring (identifying most wanted criminals/suspects). In addition, non-cooperative iris recognition systems can provide added convenience for cooperative users for identification. However, it is challenging to design an iris recognition system that can work in a non-cooperative situation, where the image quality may be low and the eye may be deformed, due to a non-frontal gaze. In the past, several researchers have worked on non-ideal iris recognition. But only a few have worked on non-frontal iris recognition. In the literature, for non-frontal iris recognition, researchers often proposed to use affine transform to transfer the off-angle iris patterns to a central frontal view. However, these methods are limited because the affine transformation assumes the iris is planar, whereas in fact it is a three-dimensional structure.

The challenges in non-cooperative iris recognition are in image segmentation and feature extraction. For image segmentation, we proposed a video-based non-cooperative iris image segmentation scheme that incorporates a quality filter to quickly eliminate images without an eye, employs a coarse-to-fine segmentation scheme to improve the overall efficiency, uses a direct least-squares fitting of ellipses method to model the deformed pupil and limbic boundaries, and develops a window gradient-based method to remove noise in the iris region. A remote iris acquisition system is set up to collect non-cooperative iris video images. An objective method is used to quantitatively evaluate the accuracy of the segmentation results. The experimental results demonstrate the effectiveness of this segmentation method. This method is accepted for publication in the IEEE Transactions on Systems, Man, and Cybernetics, Part B in 2010. For feature extraction, we first proposed the Regional Scale Invariant Feature Transform (SIFT) approach for non-cooperative iris recognition which works for off-angle iris images. Iris features are described without a polar or affine transformation and the feature point descriptors are scale and rotation invariant. However, the iris region consists of both noise and patterns, and Regional SIFT describes the area around a feature point using gradient information; this is not best suited for feature extraction. Most importantly, Regional SIFT would not work well with local pattern deformation. Recently, we proposed a Gabor Descriptor-based method for iris feature extraction. The proposed Gabor Descriptor based method has four novelties as compared to the previous works: 1) To better extract the iris features, we incorporated Gabor wavelets with SIFT for feature extraction. 2) Both the phase and magnitude of the Gabor wavelet output are weighted and fused in a novel way for local feature point

description. 3) To compensate for iris local deformation due to dilation/contraction and off-angle image acquisition, provide global registration information of the feature points, and improve the matching efficiency, we used two feature region based methods and ensured that each sub-region was locally adjusted to the dilation/contraction/eye deformation. In this research, we propose two sub-region maps for each image for feature point detection. 4) To be tolerant of segmentation error, we allowed the feature point from one image to match with feature points in its nearby locations from another image. We then integrated the proposed segmentation, image quality measure, and the Gabor Descriptor-based feature extraction and matching method together into a non-cooperative iris recognition system. The proposed system can accurately recognize a person over 10 feet away if we can obtain his/her eye at any angle. The non-cooperative iris recognition project has been sponsored by ONR and IUPUI. We have applied for several patents for this system and currently, several companies are negotiating the final license draft with IURTC to help develop and commercialize this system. I am honored to receive the ONR YIP award for this project.

All the above methods are proposed to work in Near Infrared (NIR) situations. In visible wavelengths, it would be hard to perform human identification for dark color irises. Sclera can provide additional information. We are working on designing a new method/algorithm for sclera recognition and combine the sclera and iris together for human identification for non-cooperative and visible wavelength situations. The initial research has resulted in one patent application. This research is sponsored by ONR and IUPUI.

Currently, biometrics is becoming an important method for human identification. However, if a biometric pattern is stolen, the user will quickly run out of alternatives and all the applications where the associated biometric pattern is used become insecure. Cancelable biometrics is a solution. However, traditional cancelable biometric methods would reduce the recognition accuracy. In this research, we are focusing on designing the new cancelable biometrics scheme that not only can achieve “cancelability” but also can increase the recognition accuracy. The initial research has resulted in one patent application. This research is sponsored by IU Center for Applied Cybersecurity and Research (CACR) and IUPUI.

My team actively participates in the professional level iris competitions organized by the National Institute of Standards and Technology (NIST): the Iris Challenge Evaluation (ICE 2005) and the Multimodal Biometrics Grand Challenge (MBGC) in 2008. In MBGC, we were one of four international research teams who submitted iris recognition results.

In additional to biometrics, I would like to continue working on image processing and pattern recognition. One example is the vehicle tracking and traffic monitoring. We have designed a dynamic content based image segmentation method for vehicle tracking and traffic monitoring. Only initial lane information is needed for camera calibration. The system will automatically detect the direction of the traffic flow for vehicle detection and traffic monitoring. This research is collaboration among IUPUI, Purdue University West Lafayette, and Indiana Department of Transportation (INDOT) Research Division. This project is sponsored by INDOT. The expansion of such a system to the multi-server and distributed network was sponsored by NSF.

I understand the importance of multidisciplinary research and collaborations with other professionals in and outside of the university. I have worked with students from different academic backgrounds in three MURI projects. I am a member of two IUPUI signature centers: Transportation Active Safety Institute (TASI) and Androids. Both centers are multidisciplinary based and focus on different perspectives that are important and unique for IUPUI. In addition, I worked with my colleagues from our department in biometrics and pattern recognition, colleagues from technology departments in our school in NIH AHRQ project to design an automatic hand hygiene monitoring system, colleagues from ME department in automatic heat flow detection for the human body, colleagues from school of Informatics in Androids research, and colleagues in the medical school at IUPUI for medically related research. Also, I am expanding research collaborations with professors from other universities, such as professors from Purdue University Lafayette in a workload evaluation project, professors from the US Naval Academy in image

quality measure, and professors from University of Maryland School of Medicine in confocal imaging research.

With the world becoming smaller and smaller, I believe it is important to engage in International collaboration in research and education. The IUPUI International Development Fund (IDF) provided me seed money for international collaboration with Dr. She in Tokyo University of Technology. A student of mine and I visited Japan in the Summer of 2008 and Prof. She visited us in Jan. 2009. Our research resulted in one international conference and working on one journal article that is to be submitted to IEEE Transactions of Industry Electronics. Recently, we expanded this project to a proposal for NSF Partnerships for International Research and Education (PIRE) program. Even though it was not funded, this proposal helped expand my collaboration with more researchers and universities in the USA and Japan.

Currently, I am working with researchers from University of Toronto, and several Canadian government agencies in biometrics related area. Our first pilot project has been funded by Canada Department of Defense in 2010. If this project is successful, it could be expanded to more interesting international collaborations and research projects.

In summary, I have been very active in my research and have a track of record of success during the past five years. I have been very devoted to multidisciplinary and international education and research. I would like to continue my current research and expand my collaboration with other faculty members, industry, and government to pursue more research and funding opportunities.

TEACHING

I believe learning is an active process that requires the participation of students. A positive, trusting, and encouraging learning environment is the key to ensure effective teaching. The most important element of teaching is not lecturing on the material itself, but engaging students in critical thinking and motivating them to practice and pursue future learning.

I have successfully combined my research with my teaching and developed a new course named Biometrics (previously experimental course ECE 595 and now permanent number ECE 510). In this course, I have developed two major hands-on projects for the students. The first one is to design a face recognition system using Principle Component Analysis (PCA) and Fisher Linear Discriminate Analysis (LDA). The students are asked to design their own face image segmentation method and are encouraged to revise PCA and LDA methods to be tolerant of the segmentation error. For the final project, they are asked to design a multimodal biometric system incorporating face recognition and iris recognition. It is more open-ended than the first project and has more design components. They need to design their own application scenario and their multimodal strategy accordingly. They also need to take their own recognition accuracy and other system performance capability into account. In this way, they will have both theory implementation components and design components. They are implementing PCA and LDA theories for face recognition, and Gabor wavelet for iris recognition. But at the same time, they are designing the preprocessing, post-processing, identification methods, human-machine interface, and identification strategy. More importantly, every student needs to present their design, strategy, and results in the class, which helps them to learn to express themselves in public. Many students reported that they had learned a great deal from this course. Lately, this course has been selected to co-list in the Department of Computer Science.

I also taught and significantly revised ECE 662 Pattern Recognition and ECE 595 Information Theory by adding hands-on elements to them. The students liked to design their own systems while, at the same time, using the theories.

I have taught the following courses at IUPUI: ECE 510 Biometrics, ECE 595 Information Theory, ECE 305 (with Dr. Rizkalla), ECE 302, ECE 202, ECE 301, and ECE 662. The students' feedback and surveys have been very positive. Overall, my teaching evaluations are excellent. Most importantly, the students in

my class feel very comfortable to ask me questions, challenge textbook/published theories, and discuss with me their thoughts/ideas.

I have also played a key role in department curriculum and school/department recruiting at IUPUI. I am an active member of the undergraduate curriculum committee, which helps the department to develop new curricula. I have been active in helping the school and department by giving lectures/seminars/small talks to a number of interested high school students, undergraduates, and dual degree students about biometrics. Many in the audiences ended up being our students.

Every year, I mentor several undergraduate students in their research projects/independent studies besides supervising graduate student theses. I have been a mentor for senior design projects, MURI, UROP, McNair, and the Minority Student Research Programs. My research lab has been used to support the mission of education. My teaching experience has been published in two peer-reviewed journal articles, and one international conference paper. I am honored to receive two university-level teaching related awards.

Currently, I have 2 proposals pending in the Department of Homeland Security. One is to establish and develop honor homeland security undergraduate program at the electrical and computer engineering department for underrepresented students. I am the PI for this proposal. The other one is to establish an honor homeland security BS and MS integration program in electrical and computer engineering. I am a key Co-PI for this proposal. If funded, these programs will provide funding to students, especially underrepresented students, to pursue honors program in our department.

SERVICE

I have been privileged to serve on our department's graduate committee (2005), as seminar coordinator (2007~2009), on the undergraduate curriculum committee (2006-present), the graduate admission committee (2007~present), on our school's research committee (2007-present), as a school senator (2009~present), and on the Dean Search committee (2010). Recently, I was appointed to be a member of the Faculty Handbook Standing Committee. These services helped me to learn a great deal about our department, other departments in the school, and many positive facts about IUPUI.

I am extremely proud to have opportunities to show our lab and demonstrate our research results to high school students, undergraduate students, dual degree students, industry guests, and Purdue trustees and the Purdue president. In addition, I have been helping my peers in research and proposal development and providing help, support, and advice to students regarding their study, research, and career.

I have been very active in professional organizations and related groups. I have been invited to be a committee member and section chair for conferences, and a reviewer for proposal panels, journals, conferences, and books.

SUMMARY AND FUTURE DIRECTIONS

In summary, I am on the track for the Promotion and Tenure application. As a research scholar, my areas of excellence in research are in image and pattern recognition (especially in biometrics). Particularly, my contributions in the iris recognition area are recognized by peers nationally and internationally. Over the years, I have been productive in publication, and in getting internal/external funding support. I am also pursuing international collaboration in research and education. I would like to continue my research in these areas and explore more research opportunities via cooperation with other faculty/industry/government members. As a devoted educator, I love teaching and believe in the capabilities of students. I have compiled a solid teaching record at both the undergraduate and graduate level. It is my goal to encourage and inspire more students to pursue their studies and research projects in engineering. As a good citizen in my professional community, I will continually contribute exemplary service to our department/school/university and remain active in professional organizations.