CITeR 2009
Research Portfolio

Detecting and Extracting Macro-Features in Iris Images
Arun Ross, Larry Hornak and Xin Li (WVU)

The iris exhibits a very rich texture consisting of "pectinate ligaments adhering into a tangled mesh revealing striations, ciliary processes, crypts, rings, furrows, a corona, sometimes freckles, vasculature, and other features". The randomness of the iris texture and its apparent stability render it a useful biometric. Most iris-based systems use the global and local texture information of the iris to perform matching. The anatomical structure within the iris is seldom used in the matching process. This project pursues the path of inquiry first identified in the Phase II multispectral project to design methods to extract and utilize the macro-features that are visible on the stroma of the iris. The goal is to design a system that can extract and match features across two images of the iris. The work will: (a) provide an alternate way to match iris images; (b) facilitate ways to visually compare two iris images thereby allowing forensic experts to determine the degree of similarity between two iris photographs; (c) potentially be used to locate and retrieve iris images possessing specific macro-features from a large database; and (d) provide an understanding of the individuality of the iris.

Matching and Retrieving of Face Images Based on Facial Marks: Phase 2
Anil K. Jain (MSU)

Facial marks have been studied as means of supplementing global shape and texture information used in commercial face recognition systems. The ability to automatically extract these marks or artifacts from facial images in large face databases will assist law enforcement agencies to rapidly locate human faces. In phase 1, we developed a prototype system to (i) automatically extract facial marks, (ii) designed a simple decision rule for matching facial marks, and (iii) developed a fusion rule to combine mark-based matcher with a leading commercial face matcher, and (iv) showed improved matching performance on a small face database. In Phase 2 we extend our previous study by: (i) incorporating a 3D face model to achieve pose invariance, (ii) enhance the automatic mark extraction method so that it can be applied to low-resolution video frames, (iii) investigate various fusion rules to combine these distinguishing marks with a commercial face matcher, and (iv) show performance improvement on a large (10K) database of operational images.

Models for Age Invariant Face Recognition
Anil K. Jain (MSU)

Facial aging refers to the problem in face recognition where the time difference between the enrolled face image and the query image of the same person is large (typically, several years). It is one of the major sources of performance degradation in face recognition. An age invariant face recognition system would be useful in many application domains such as locating missing children, screening, and multiple enrollment detection. However, facial aging has not received adequate attention until recently and the proposed aging models to compensate for age are still under

development. Aging related facial changes appear in a number of different ways: i) wrinkles and speckles, ii) weight loss and gain, and iii) change in shapes of face primitives (e.g., sagged eyes, cheeks, or mouth). These aging patterns can be learned by observing changes in facial appearance across different ages from a set of training subjects. This work will design and implement techniques to (a) perform facial aging modeling in 3D domain using both shape and texture, (b) build separate facial aging models for different genders and ethnicities (Caucasian, African American, and Asian), and (c) use the aging model to compensate for aging to enhance matching accuracy using a commercial face matcher.

BioFuse: A Matlab™ Platform for Designing and Testing Biometric Fusion Algorithms

Arun Ross (WVU) and Anil K. Jain (MSU)

Multibiometric systems consolidate evidence provided by multiple sources to establish the identity of an individual. The design and performance of a multibiometric system is dictated by several factors, including the number of biometric sources to be combined, the fusion architecture (e.g., serial versus parallel), the mode of operation (e.g., verification versus identification), the cost and response time of the system, and the fusion mechanism employed. Recent research in multibiometrics has resulted in the development of several algorithms for performing fusion at the data, feature, score, rank, and decision levels. Covariates such as data quality and soft biometrics have also been incorporated in the fusion framework resulting in improved matching accuracy. This work seeks to build a software platform that would provide its user with the ability to experiment with a large number of fusion methods and evaluate the relative performance of these methods on multiple datasets. Since most biometric researchers in academia utilize the Matlab™ platform to develop and test algorithms, the proposed software will be designed in such an environment. However, the graphical user interface (GUI) offered by the tool will be accessible by the broader end-user biometrics community. The salient features of the proposed environment include (a) access to a wide gamut of fusion techniques and methods to address missing/incomplete data; (b) a platform to evaluate multiple competing fusion techniques as a function of covariates; (c) the capability to incorporate fusion modules developed by other researchers; and (d) the development of a *wiki* website to allow for the collaborative editing of the software.

Large scale evaluation of quality based fusion algorithms

Bojan Cukic, Nathan Kalka (WVU) and Anil K. Jain (MSU)

Performance improvements attributed to fusion are significant and major biometric installations have deployed or plan to deploy multimodal fusion to improve identification accuracy. The deployed fusion algorithms mostly operate at the matching score level and do not always incorporate biometric quality estimates. State of the art multimodal fusion schemes adaptively incorporate quality estimates to further improve the performance. Nevertheless, due to lack of adequate volume of training data, inconsistencies in the acquisition of training and testing data, and highly conflicting unimodal evidences, these systems often do not necessarily achieve “optimality”. The goal of this project is to perform large scale evaluation of face / iris / fingerprint quality based fusion algorithms. We have access to large fingerprint and iris databases for analysis (over 8,000 subjects in each modality). This data comes from collections known to have inconsistent quality. We also intend to acquire as many face images as possible from known collections to

chimerically augment the fingerprint and iris data. We will utilize commercial matchers and publicly available quality estimation algorithms. We will evaluate quality based likelihood ratio based fusion algorithm, bayesian belief network fusion algorithm, SVM-likelihood ratio algorithm, as well as well known score level fusion approaches which do not include quality scores (sum rule, max rule, etc). For quality evaluation we plan to use WVU, MSU and our implementation of Daugman's algorithm for iris, NFIQ and BAH algorithms for fingerprints, FaceIt and BAH for face. Empirical results are expected to provide statistically significant evaluations that can guide future research and deployment decisions in multi-biometric fusion.

PRESS (Program for Rate Estimation and Statistical Summaries) version 2.0

Micheal Schuckers (St. Lawrence University) and Daqing Hou (Clarkson University)

Several years ago, we developed (with CITeR funding) the PRESS tool which is now in version 1.1. This tool has assisted many organizations in assessing and evaluating tests for biometric identification including TSA, NBSP, Authenti-Corp, Mitre, NIST. Several developments have occurred in statistical methods for biometrics since that time. We will add these new methods as well as make improvements on the existing methodology used in PRESS 1.1. These improvements include adding new statistical methods for FTE, FTA, MTT and improved methods for FMR, FNMR and ROC's. Further, we will improve the existing graphical interface.

Economical, Unobtrusive Measurement of Postural Correlates of Deception

Christopher Lovelace, Reza Derakhshani, Gregory King (UMKC) and Judee Burgoon (U of A)

This will be a novel adaptation of force platform technology to the measurement of postural shifts that accompany deception. The straightforward, inexpensive, and concealed ground force platform technology, when coupled with modern non-linear, data-driven signal classification methods, has the potential to provide efficient, reliable, and unobtrusive identification of deception in a security screening environment.

The Effect of Power and Modality on the Detection of Deception

Norah Dunbar, Matthew Jensen (Oklahoma) and Judee Burgoon (U of A)

Many field situations such as rapid screening at portals or the educing of information from witnesses or suspects involves a power differential between the interviewer and the subject. Using Computer-Mediated Communication (CMC) in these areas for initial screening interviews reduces the burden on human, physically present interviewers.

Linguistic Dynamics in Criminal Interviews

Matthew Jensen, Norah Dunbar (Oklahoma), Judee Burgoon (U of A) and Stan Slowik

The proposed research will examine the dynamics of deceptive language and content in high-stakes interviews. We expect that linguistic and context-independent content from high-jeopardy interviews will discriminate truthful or apparently truthful responses from ones that indicate deception and that deceptive strategies such as hedging, ambiguity, and equivocation will vary across the course of an interview. This work will explore whether particular phases of an interview (early, late) are more diagnostic than others regarding an interviewee's truthfulness.

Observational Coding of Deceptive and Truthful Interviewees from Varied Cultural Orientations

Judee Burgoon (U of A), Norah Dunbar and Matthew Jensen (Oklahoma)

It is more difficult for examiners to detect deception by individuals from disparate cultures because if deceiver and receiver differ even in their definitions of what constitutes deception, then they may communicate in ways that complicate detection accuracy. We will examine this issue at a global, impressionistic level that is similar to the unaided general impressions examiners form when conducting screenings and pretest interviews.

Application of Automated Linguistic Analysis to Deception Detection in 911 Homicide Calls

Mary Burns, Kevin Moffitt, Judee Burgoon, Jay Nunamaker (U of A) and Tracy Harpster (Moriane Police Department, Dayton, OH)

This work will analyze calls by 'guilty' and 'innocent' callers for a proof of concept for detection and of deception/guilt. We will apply our automated linguistic cue analysis and automated transcription tools to transcripts and/or audio tapes of 911 calls to determine guilt or innocence of the caller. Advantages of analyzing 911 statements vs. person of interest statements or interviews conducted by law enforcement officers: (1) 911 statements represent the initial contact between a caller and an emergency response team, including law enforcement, leaving callers little chance to rehearse a false story; (2) because 911 operators are not perceived by callers law enforcement, they may exhibit less controlled behavior and more cues of deception; (3) due to the temporal immediacy of the crime to the 911 call, there may be more active stress on the caller which may cause the caller to 'leak' more clues unintentionally; (4) because 911 operators do not interrogate, the statements are objective.

Using Connectionist Modeling to Automatically Detect Facial Expression Cues in Video

Koren Elder, Aaron Elkins, Judee Burgoon (U of A) and Nicholas Michael (Rutgers)

This study will build a connectionist model using facial metrics and Facial Action Coding System (FACS) to automatically identify facial expressions in videos. The connectionist network model will be trained to identify different emotion expressions (e.g. surprise, anger, happiness, suspicion, neutral, etc.). The model will then be used to map the facial expressions of interviewees captured on video. In the future, these mappings can be used to determine which expressions are reliable indicators of truth or deception during interviews or interrogations.

Collaborative Acquisition of Face Images Using a Camera Sensor Network

Vinod Kulathumani, Arun Ross and Bojan Cukic (WVU)

Network of image sensors combined with biometric systems can form the building block for a variety of surveillance applications such as airport security, protection of critical infrastructures and restricted access to guarded assets. In this project, we focus on the collaborative acquisition of biometric data for face recognition using a network of image sensors. One of the scenarios for using such a system is the distributed *in-network* detection of an event of interest and simultaneous face recognition in a dynamic scene.

As a basic step towards building such a system, we focus on the following problem statement: Given a set of *n* cameras deployed to monitor a given area, (0) determine optimal positioning of cameras to maximize biometric information obtained when a single person enters the area, (1) design a distributed algorithm to coordinate the cameras to capture partial views of the face that maximize biometric content and (2) design a distributed algorithm to acquire partial snapshots to construct the full facial image using mosaicing techniques.

LiveDet 2009-Fingerprint Liveness Detection Competition 2009

Stephanie Schuckers and Bozhhao Tan (Clarkson)

Fingerprint recognition systems are vulnerable to artificial spoof fingerprint attacks, like the molds made of silicone, gelatin or Play-Doh, etc. "Liveness detection" has been proposed to defeat these kinds of spoof attacks. We propose to host the first fingerprint liveness detection competition (LivDet2009) in ICIAP 2009. This competition will be hosted in collaboration of University of Cagliari (Gian Luca Marcialis, Fabio Roli, Pietro Coli), also active researchers in liveness detection. The goal is this competition is to compare different methodologies for software-based fingerprint liveness detection with a common experimental protocol and large liveness dataset. The ambition of the competition is to become a reference event for academic and industrial research. This competition is open to all academic and industrial institutions which have a solution for software-based fingerprint vitality detection problem. Each participant is invited to submit its algorithm in Win32 console application. The performance will be evaluated by utilizing a very large data set of "fake" and "live" fingerprint images captured with three different optical scanners. The performance rank will be compiled and published in this site and the best algorithm will win the "Best Fingerprint Liveness Detection Algorithm Award" at ICIAP 2009.

On the Super-Resolution of Iris Images from Video Streams

Patrick Flynn (Notre Dame) and Arun Ross (WVU)

Current trends in iris recognition deployment expectations include (a) the use of video sensors to acquire video sequences of images, and (b) the need to exploit images acquired under non-ideal circumstances. Currently available iris matchers perform poorly on iris images that are low in resolution. Since non-ideal circumstances may preclude camera repositioning to improve resolution, investigation of resolution improvement through multi-frame integration is a topic of interest. We propose to combine our expertise in image processing, iris imaging, and video analysis to integrate multiple video frames of an iris to form a super-resolution still image suitable for matching. We will explore two scenarios to facilitate super-resolution. In the first scenario, a single camera will be used to acquire a video stream of a live iris (single view system); in the second scenario, two cameras, offset by a pre-determined inter-axial distance, will be used to acquire multiple video streams of a live iris (multi-view system).

Unconstrained Face Recognition Under Non-Ideal Conditions

Arun Ross (WVU) and Anil K. Jain (MSU)

The matching performance of face recognition systems has significantly improved over the past decade as assessed by FRVT/FRGC evaluations. However, the fundamental

problem of matching face images obtained using different cameras and/or subjected to severe photometric (e.g., illumination) and geometric (e.g., compression) transformations continues to pose a challenge. For example, it is difficult to match a high-resolution face image obtained under controlled illumination against a low resolution face video hosted at YouTube or a geometrically resized face image posted on the web. In this work, the problem of matching face images whose intrinsic image characteristics are substantially different will be investigated. The goal is to design algorithms that can handle the problem of matching disparate face images of the same individual.

Phase 1 – Participation in the Multi-Biometric Grand Challenge

Stephanie Schuckers (Clarkson), Natalia Schmid (WVU) and Besma Abidi (UTK)

Fusion of face and iris data at a distance for biometric recognition could be extremely beneficial in places, like airport, port of entry, etc. The Multi-Biometric Grand Challenge goal is to provide various recognition challenges for face and iris based on still and video imagery. Our previous work includes efforts in face and iris recognition using advanced adaptive algorithmic approaches to account for non-ideal conditions through preprocessing, segmentation, modeling and utilization of global iris quality. We propose to participate in the Multi-Biometric Grand Challenge (MBGC). MBGC has three stages. (1) Challenge 1 data was made available in May 2008. Results were presented in Dec 2008 at a workshop. (2) Challenge 2 dataset with results are presented in Spring 2009. (3) The last stage is the Multi-Biometric Evaluation in Summer 2009. Our approach will be to fuse biometric information from both face and iris extracted over multiple frames. Quality information will be a critical component to select individual frames and to weigh information at the feature/pixel level. Fusion will be considered at the match score level and feature level where PDE-texton maps or other features can be used to jointly encode to obtain robust representation of face and iris.

Evaluating and Integrating Speech Recognition Software into Agent99 for Real-Time Deception Detection

Kevin Moffit, Sean Humphries, Jay Nunamaker, Judee Burgoon and Pickard Burns (U of A)

The successes of automated post-processing of text for linguistic credibility assessment are well-documented. (Zhou et al., 2004, Moffitt et al., 2008). Yet real-time processing of interviews and dialogue using these tools has yet to take place. For real-time processing to occur, words must be transcribed to text as they are spoken. This is accomplished by speech recognition (SR) software. SR software has a history of being inaccurate and difficult to use; however some SR software companies now claim 95% accuracy. The medical industry has now embraced SR software to cut the time in preparing patient reports (Alapetite et al. 2008). Even so, integrating SR into the linguistic credibility process has remained untried and the reliability of SR software as a tool for gathering interview data and dialogue has yet to be evaluated. In this project, we will build a real-time speech evaluation system which integrates SR with Agent99, leveraging software previously developed for linguistic credibility assessment.

Handedness in Detecting Deception in Cultural Interviews

Mathew Jensen (Oklahoma), Thomas Meservy (UM) and Judee Burgoon (U of A)

Kinesic analysis has been successfully used to discriminate truth from deception in numerous experimental settings. A curious finding that has repeatedly surfaced is the

predictive value of cues related specifically to the left hand. Two alternative explanations will be addressed in the proposed research. One is that differences stem from brain lateralization (each hemisphere has functional specialization) such that the left hand performs different discursive functions than the right. The other is that the effects are due to handedness and observed left-hand effects pertain only to those with right-hand dominance. We will use data collected on subject handedness to (a) replicate the hand-related effects and (b) determine if they are linked specifically to hand dominance or question type or both.

Looks Like Me: Cultural Avatars

Koren Elder, Mark Patton, Aaron Elkins, Carl and Judee Burgoon (U of A)

This study will conduct a lab experiment to empirically test how the gender and ethnicity of avatars can be manipulated to elicit cues that are reliable indicators of truth or deception. The credibility of the avatar and the reactions of the subject will be investigated to determine if there are significant differences based on avatar and subject gender and ethnicity interactions and which avatars best expose deception without creating confounding arousal unrelated to deception. With the increase in use of avatars for kiosks, it is important to understand how the embodiment of an online agent can impact interpersonal communications.

CITeR 2008
Research Portfolio

An Acquisition Platform for Non-cooperative, Long Range Ocular Biometrics

Reza Derakhshani (UMKC), Plamen Doynov (UMKC) and Besma Abidi (UTK)

The objective of this proposal is to mitigate this problem by a COTS-based capturing platform that will (a) scan a crowd using multiple, pan-tilt systems, (b) locate subjects' eyes in near-infrared (NIR) (c) tag each locked-on individual with a NIR pattern for concurrent, multi-subject recognition (d) using burst (lucky) imaging, pick the best high-zoom images of the eye regions by fast quality analysis algorithms for long-range (up to 10m) and simultaneous ocular biometric recognition of unconstrained, freely moving crowds.

Automatic High Resolution Palmprint Matching System

Anil K. Jain (MSU) and Arun Ross (WVU)

Palmprints contain three different levels of information: Level 1 (principle lines, wrinkles and major creases), Level 2 (minutiae points) and Level 3 (ridge contour, pores). While Level 1 features can be extracted from fairly low resolution images (~100 ppi), higher resolution images are needed for extracting Level 2 (~500 ppi) and Level 3 (~1000 ppi) features [4]. Commercial palmprint acquisition systems do have the capability of capturing dual-resolution images (500 and 1000 ppi), but not much work has been done to date in extracting Level 3 features from 1000 ppi images (ANSI NIST document on Extended Feature Set for fingerprint and palmprints [5]). Matching latent (partial) palmprints to full prints is particularly important in forensics application where Level 3 features will play a major role. In this project, we propose to design and evaluate an automated palmprint matching system that uses multiple levels of features.

Culturally Specific Credibility Classification Using Layered Voice Analysis

Judee Burgoon, Aaron Elkins, Douglas Derrick, Josh Hottenstein (U of A) and Dale Tunnell (Forensitec)

These newly available vocal measurements will provide a rich platform for examining the moderating effect of culture on deceptive leakage cues, particularly vocalics. Culture has been virtually unexplored in this context despite its potential to explain some of the individual variability in verbal and nonverbal behavior expressed during deceptive communication. The findings from this research have the potential to improve existing classification models utilizing other behavioral cues to detect deception. The credibility classification model for LVA will be developed using statistical analysis and machine learning algorithms on training data from a recent deception study focused on culture. Additionally, we will provide an empirical evaluation of the new generation of commercial LVA currently in use by law enforcement agencies.

Establishing Chain of Evidence in Biometric Systems

Bojan Cukic, Arun Ross, Nathan Kalka and Nick Bartlow (WVU)

The process of creating such a chain entails at least three types of validation to provide assurance that the collected biometric evidence has not been fabricated, altered or unintentionally mislabeled. These are validation of (a) evidence transmission, (b) content integrity, and (c) source of origin. While modern cryptography can adequately handle the

validation of evidence transmission, validation of content integrity and source of origin must rely on other techniques. Biometric watermarking is the process of clandestinely embedding data into biometric images which can be used to assure validity of content. Digital hardware fingerprinting allows for the identification of source hardware from which an image originated. Through analysis of various types of sensor pattern noise and other artifacts, one can determine the technology, brand, model or specific sensor used to capture a biometric image. By utilizing cryptography, watermarking in conjunction with digital hardware fingerprinting and cryptography, a chain of evidence can be created, providing verification of image origination, authenticity, integrity, ownership, and non-repudiation of origin.

Improving the Identification of Fraud by Adding Word Sense Disambiguation to Linguistic Credibility Assessment/Enhancing Fraud Detection by Building Lexicons and through Collocation Techniques

Sean Humphreys, Kevin Moffitt, Judee Burgoon and Jay Nunamaker (U of A)

Automated techniques have been developed to assist in detecting deceit and fraud. However, existing models (e.g. Zhou et al. 2004) rely on proper identification of part-of-speech tags (nouns, modal verbs, adjectives, etc) and can be harmed by ambiguous words. Deceivers are thought to use more ambiguity and hedging language. Computes are not nearly as good as humans at disambiguating words and their parts-of-speech. Errors in these automated tools can cause deception detection models to misclassify statements and documents. Using field data collected from the fraudulent SEC filings and insurance fraud, a linguistic analysis that includes a word sense disambiguator (WSD) will be undertaken to assess credibility and identify distinguishing linguistically cues related to credibility in text-based claims.

Improving Quality Enhanced Biometric Fusion Schemes

Bojan Cukic, Afzel Noore, Nick Bartlow, Nathan Kalka, M. Vasta and R. Singh (WVU)

To design a hybrid fusion algorithm which combines the three approaches along with the uncertainties and precision of individual classifiers to improve the performance in cases of conflicting or missing information. Our hybrid classifier will decrease the computational complexity of resolving cases with conflicting unimodal evidences. Additionally, we will augment existing algorithms through the incorporation of a probabilistic measure of decision dependability which affords the opportunity to perform decision rectification or "reversing" classification decisions likely to be inaccurate. Through careful application of decision rectification, performance of quality enhanced biometric fusion algorithms may be improved. In both the proposed hybrid fusion algorithm and the existing algorithms augmented with decision rectification we expect to observe increases in performance when low quality samples are injected into systems previously trained on high quality subsets. Performance evaluation will be conducted using standard statistical measures (ROC curve) and through cost curves.

Matching and Retrieving of Face Images Based on Facial Marks

Arun Ross (WVU) and Anil K. Jain (MSU)

Face recognition systems typically encode the human face by utilizing either local or global texture features. Local (or part-based) techniques first detect the individual components of the human face, prior to encoding the textural content of each of these

components. Global techniques, on the other hand, consider the entire face as a single entity during encoding. However, both these techniques do not explicitly extract wrinkles, scars, moles, and other distinguishing marks that my present in the 2D image of the face. Many of these features are temporally invariant and can be useful for face recognition and indexing. The ability to automatically extract these marks or artifacts from facial images in large digital libraries can assist law enforcement agencies to rapidly locate human faces possessing specific marks. This proposal will design and implement techniques to (a) extract distinguishing marks present of the surface of the face and analyze their distributions, (b) efficiently retrieve face images from a digital database based on these marks, and (c) combine these distinguishing marks with a commercial texture-based face matcher in order to enhance matching accuracy.

Phase 0 - Participation in Multibiometric Grand Challenge

Stephanie Shuckers (Clarkson), Natalia Schmid (WVU), Besma Abidi and Uma Kandaswamy (UTK)

Fusion of face and iris data at a distance for biometric recognition could be extremely beneficial in places, like airport, port of entry, etc. The MultiBiometric Grand Challenge goal is to provide various recognition challenges for face and iris based on still and video imagery. We propose to participate in the MultiBiometric Grand Challenge (MBGC). MBGC has three stages. (1) Challenge 1 data is made available in May 2008. Results are to be presented in Dec 2008 at a workshop. We are processing the data now. (2) Challenge 2 dataset with results are presented in Spring 2009. (3) The last stage is the MultiBiometric Evaluation in Summer 2009. Our approach will be to fuse biometric information from both face and iris extracted over multiple frames. Quality information will be a critical component to select individual frames and to weigh information at the feature/pixel level. Fusion will be considered at the match score level and feature level where PDE-texton maps or other features can be used to jointly encode to obtain robust representation of face and iris.

Psychophysiological Biometrics

Judee Burgoon (U of A), Reza Derakshani (UMKC), Arun Ross (WVU) and Diane Filion (UMKC)

We will utilize stimulus-response psychophysiological reactions of individuals that can be captured by the typical biometric platforms in order to enhance their performance and security via imposter detection. We will focus on the well known pupillometry, blink, gaze, and other deception-induced gestures of an individual such as hand and head gestures while interacting with the biometric system or an interrogator. In addition to the detection of imposters, the above psychophysiological traits should provide strong anti-spoofing measures. This project would serve as a synergistic project between CITeR-WVU and the new CITeR-UA.

Rapid Assessment Using Kiosk-based Interviews

Mark Patton, Judee Burgoon and Jay Nunamaker (U of A)

This is a first effort to utilize an automated rapid assessment kiosk to evaluate subjects for truth or deception. Subjects will be run through an international airline travel scenario where they will pack bags and proceed through a screening kiosk. Subject may or may not have items which are contraband or illegal for this type of travel. They will be asked a series of screening questions intended to elicit if they have anything to declare or if they

are carrying any proscribed items. There actions during the question and answer interacts will be video tapes, and their audio responses captured, for subsequent analysis. The experiment is intended to determine if standing subjects reveal stress or deception through body movement, if Voice Stress technologies can successfully flag either stress or deception in this setting, or if a fusion of these technologies can reveal stress and/or deception. It is also intended to reveal if there is any material difference based on method of questioning, either a speaking avatar or text on a screen which is read aloud to the subjects.

Sequential Biometric Fusion Involving Incomplete or Missing Data

Arun Ross (WVU) and Anil K. Jain (MSU)

This proposal seeks to address this problem in the context of an *identification system* by raising two pertinent questions. (a) Can a fusion algorithm be designed such that biometric information is consolidated in a sequential manner (as the traits become available) in order to determine an individual's identity? (b) Can a score-level or rank-level fusion scheme be designed to work in the presence of partial or incomplete biometric information? We will extend our current approach based on the Likelihood Ratio technique to devise methods that can effectively answer these questions thereby advancing the state-of-the-art in biometric fusion for *identification* systems.

Iris Recognition Beyond 1000nm: A Preliminary Study

Arun Ross, Lawrence Hornak and Xin Li (WVU)

Most commercial iris recognition systems utilize information available in the 700 – 900nm spectral band (near-IR). Here, we investigate the possibility of performing iris recognition at higher wavelengths (1000 – 1500 nm, i.e., extended near-IR) to advance the science and technology of multispectral iris analysis in the biometric domain. The goal of this project is (a) to understand the composition of the iris at multiple resolutions using spectral information beyond 1000 nm (much like the Level I, II and III details in fingerprints); (b) to determine if iris segmentation can be successfully accomplished at these wavelengths; (c) to develop anti-spoofing methods by studying the information revealed by various components of the eye at these wavelengths; and (d) to report recognition performance using multispectral information associated with these spectral bands.

Autonomous Interrogation through Synchronous Computer-Mediated Communication

Matthew Jensen, Douglas Derrick and Judee Burgoon (U of A)

We will utilize artificially intelligent "chatbot" technology and advanced text processing algorithms to create a prototype autonomous interrogation system. The artificial integrator will have the ability to interact with a subject via synchronous communication (i.e., chat). In order to conduct the interrogation, the computer-based agent will use a series of internal scripts and a complicated decision tree. The agent will ask questions of the subject, and process the responses in real-time in two ways. First, it will analyze the communication for potential deception using GATE / WEKA libraries and a text-based deception model. Second, it will weigh the deception measurement and original message content against its decision tree and then formulate its response or next question.

Hybrid Expert System for Credibility Assement

Matthew Jensen, Jay Nunamaker and Judee Burgoon (U of A)

Among the most discriminating cues to deception are perceptual measures such as observed uncertainty, cognitive load, and non-immediacy. We will incorporate such perceptual measures in an existing prototype that uses linguistic and kinesic analysis for credibility assessment. Such a hybrid expert system would include more of the unique capabilities that are necessary for unobtrusively monitoring interactions for indications of deceit and should improve credibility assessment performance.

Kinesic Credibility Assessment of Criminal Interviews

Matthew Jensen, Judee Burgoon (U of A), Amy Franklin (Rice—Linguistics) and Pete Blair (Texas State U—Criminal Justice)

Kinesic analysis has been successfully used to discriminate truth from deception in numerous experimental settings. However, these experimental settings do not provide representative levels of deceiver motivation and jeopardy that are present during high-stakes deception. For this project, we will have access to a new dataset that contains interviews captured during actual criminal investigations. Ground truth for all interviews has been established by confession or conviction of the suspect. Using this dataset, we will be able to further probe the capabilities of kinesic credibility assessment by using field data.

CITeR 2007
Research Portfolio

Recovering the Frontal Facial Image from Surveillance Video

Besma Abidi (UTK) and Arun Ross (WVU)

The objective of this proposal is to construct an optimal frontal view from a series of frames obtained from surveillance video. Two techniques (2D and 3D) will be implemented and compared in terms of real time requirements and performance of a recognition engine. The study will be conducted on a variety of sample videos to mimic various real life scenarios and performance evaluated using existing surveillance databases.

Quality Based Restitution of Iris Features in High Zoom Images for Less Constrained Iris Recognition System

Stephanie Schuckers (Clarkson), Natalia Schmid, Aditya Abhyankar and Lawrence Hornak (WVU)

This necessity to have short range eye scanner distance poses a serious limitation in terms of their usability. "Iris recognition from distance' has received limited attention in literature and is a very challenging problem for the following reason: (1) Lang range distance degrades the overall iris quality. (2) The effect of various noise elements like motion blur, angular deformation etc. gets amplified with the distance. (3) As distance increases, iris recognition techniques for restoration of important iris features from high resolution iris images for efficient long range iris recognition. Following issues will be studied: (1) Design of eye-scanner distance base adaptive quality metric. (2) Study and analysis of various iris features at different resolutions. (3) Adaptive quality metric based iris segmentation and encoding methodologies. (4) Development of reliable way of formulating distant iris templates using quality restitution of iris features for more dependable recognition with fewer constraints.

Automatic High Resolution Retrieval of Tattoos for Victim and Suspect Identification

Anil K. Jain (MSU)

Tattoos are imprints on the skin useful for identifying the non-skeletalized body of a victim, or a suspect using a false identity. Tattoos also serve as an indicator of social status, personality, religious affiliations, or criminal organization affiliation of individuals. A wide cross section of the population bears tattoos, from fashion models to known criminals and gang members. Various law enforcement agencies maintain a database of scars, mark & tattoos for the purpose of victim and suspect identification. For this reason, 'ANSI/NIST – Data Format for the Interchange of Fingerprint, Facial, & Scar Mark & Tattoo Information' was released to ensure uniformity in the capture and exchange of tattoo data. This protocol utilizes semantic (category) labels (viz., "human forms and features", "animals", "plants", etc.) to characterize each tattoo entry during data collection; the retrieval is, therefore, primarily based on textual queries. This matching and retrieval method is not only time consuming, but lacks objectivity. Image or pattern-based retrieval, on the other hand, is more appropriate since it lends itself to automated queries based on the content of visual imagery or pattern. We propose to

design and build a prototype tattoo matching and retrieval system based on image content and semantic categories

Securing Multibiometric Templates Using Fuzzy Vault

Anil K. Jain (MSU) and Arun Ross (WVU)

Template security is critical in biometric system design because stolen biometric templates, unlike passwords, cannot be revoked. A number of approaches, including encryption, watermarking, fuzzy vault and revocable template have been proposed to secure templates. However, these approaches have been proposed primarily to secure a single template. A multibiometric system requires the storage of several templates for the same user corresponding to different biometric sources. Therefore, template security is even more critical in multibiometric systems. While it is possible to apply the template protection schemes individually to these templates and combine the authentication results at the decision level, such an approach is not optimal in terms of accuracy and security. We propose a unified scheme to secure multiple templates by (i) transforming features from different biometric sources (e.g., fingerprint minutiae and iriscodes) into a common representation, (ii) performing feature-level fusion to improve recognition accuracy, and (iii) constructing a single *fuzzy vault* to secure the fused multibiometric template. We will develop a fully automatic implementation of a multibiometric fuzzy vault that can handle different scenarios such as multiple samples (e.g., two impressions from the same finger), multiple instances (e.g., left and right irises) and multiple traits (e.g., fingerprint, face and iris). We will demonstrate the performance of the proposed multibiometric fuzzy vault in terms of its accuracy and security on public domain (WVU, FVC, CASIA and XMVT) databases.

Indexing Large-scale Multimodal Biometric Databases

Anil K. Jain (MSU) and Arun Ross (WVU)

Efficient retrieval of pertinent identities from a multimodal biometric database is a challenging task due to the large number of enrolled subjects and the availability of multiple biometric traits corresponding to each subject. Identification systems requiring a short response time will, therefore, be at a disadvantage when searching through the entire database to determine the identity of an individual. This project will explore the design of indexing (or filtering or binning) schemes to define an efficient search and retrieval strategy in multimodal biometric databases. Given the input biometric data of an individual, the goal of indexing is to reduce the search space of possible identities by appropriately partitioning the target biometric database. Further, indexing is likely to increase the overall matching accuracy. While such schemes exist for individual modalities such as fingerprints, multimodal indexing is a yet unexplored problem and has the potential to facilitate rapid and accurate search operations in large-scale multimodal databases.

CITeR 2006
Research Portfolio

Adaptive Biometric Authentication using Dempster-Shafer Networks: Concepts and Performance

Bojan Cukic, Natalia Schmid and Nick Bartlow (WVU)

This project aims at providing a methodology for designing Dempster-Shafer (D-S) belief networks that optimize identity matching. D-S belief networks can be automatically generated as system parameters and available evidence are updated. The strength of "knowledge" rests on a justification of belief acquired through the mathematical theory of evidence. Ideally the ability to automatically adapt will allow system performance to reach its full potential. This project will evaluate performance measures in these complex biometric systems, for example robustness and scalability, in order to understand whether the promise of performance improvement is justified. The measures will be compared against achievable limits.

Enhancing Iris Systems using Conjunctival Vascular Patterns

Reza Derakhshani (UMKC) and Arun Ross (WVU)

The conjunctival vascular structure of the eye will be used in conjunction with the iris pattern in order to validate the liveness of the iris, and enhance the recognition performance of an iris system.

Fingerprint Matching Using Level 3 Features

Anil K. Jain (MSU)

Fingerprint friction ridge details are generally described in a hierarchical order at three different levels, namely, Level 1 (pattern), Level 2 (minutiae points) and Level 3 (pores and ridge shape). Although Level 3 features are key for latent print examination and forensics research has shown the viability of using pores to assist identification, current Automated Fingerprint Identification Systems (AFIS) rely only on Level 1 and Level 2 features. With the advances in sensing technology, many commercial live-scan devices are now equipped with high resolution (1000 ppi) scanning capability, allowing additional information besides minutiae, such as Level 3 features to be utilized. We propose a systematic study to determine how much performance gain one can achieve by automatically extracting and matching Level 3 features. Our initial experiments have shown that the use of Level 3 features provide a relative reduction of 20% in the equal error rate (EER).

Multispectral and Multiframe Iris Analysis: Phase II

Arun Ross, Lawrence Hornak and Xin Li (WVU)

Phase I of this project had explored the potential of using multispectral information to enhance the performance of iris recognition systems. In phase II the goal is to develop and implement algorithms that impart the following functionalities to an iris recognition system: iris localization using multispectral information; determining an optimal color space for iris texture analysis and processing; designing new algorithms for extracting novel features from various spectral channels; automatic clustering of iris components

based on color information; fusing multispectral information based on eye color; and facilitating interoperability between iris images acquired at multiple wavelengths. By adopting this new research agenda, the PIs expect to advance the science and technology of multispectral iris analysis in the biometric domain.

Video-based Metrology for Automated Human Identity Profiling

Don Adjeroh, Xin Li, Arun Ross and Bojan Cukic (WVU)

In this project, we propose to explore a new direction in human identification that does not rely on predefined patterns. That is, we construct a person's biometric profile (BP) by extracting metrological information about the individual from a given observation data. Such a metrology-based biometric profile is both dynamic (it varies along with the acquisition environment) and scalable (more measurements imply less uncertainty about the identity). The video metrology –based approach is particularly suitable for some applications where traditional biometrics are not applicable (e.g., masked, or uncooperative individuals, or extreme environments, for instance, combat soldiers in full gear, in a hazardous environment.

Sequential Testing for Biometric Error Rates

Michael Schuckers (St. Lawrence University)

In this project, we would like to develop and apply the statistical methodology for sequential testing to the testing of bio-authentication devices. Specifically, we are interesting in testing whether or not a device's error rate is below a given threshold. The basic idea of sequential testing, as it applies here, is that periodically testing will be stopped and evaluation of the error rate at that juncture will be determined. At each such stopping point, there are three options. First, if the error rate is sufficiently low, then the test is terminated and the device is said to meet the threshold. Second, if the error rate is sufficiently high, then the test is terminated and the device is said to ***not*** meet the threshold. Finally, if the error rate is neither sufficiently large nor extremely small then the test is continued until the next stopping point.

Encryption of Biometric Templates using Biometrics as the Key

Stephanie Schuckers and S. Kumar (Clarkson)

Biometric information is irrevocable and hence should not be compromised. With the advent of applications requiring transmission of biometric information using public networks for personal authentication, it has become necessary to embed strong security in the system. Previously, key-based approaches have been suggested, but keys are often protected by passwords which often are chosen such that they are inherently weak. Our project studies methods to encrypt a biometric template by using biometric information itself instead of using keys. The proposed systems has these main components: Encoder: statistical template learning for a set of registered users to be used with partial biometric data to formulate encryption key; Simulation of a chaotic channel by mixing different biometric representations based on statistical properties of biometric data; Decoder: design of a blind source separator in tandem with hidden markov model for fuzzy matching, trained to quantify the information related to the set of registered users; and an evaluation platform to assess system performance on real as well as manipulated database.

Quality Assessment and Restoration of Face Images in Long Range/High Zoom Video

Besma Abidi (UK) and Natalia Schmid (WVU)

The objective of this proposal is to design an efficient algorithm for the evaluation of face image quality in high magnification surveillance videos, then apply adaptive image deblurring and restoration to increase the quality of these face images so they become suitable for recognition. Tests will be conducted using FaceIt.

A Dynamic Hierarchical Fusion Architecture for Biometric Systems

Anil K. Jain (MSU) and Arun Ross (WVU)

The performance of a biometric recognition system can be significantly improved by combining multiple classifiers, by utilizing multiple samples during enrollment/authentication, or by including multiple biometric indicators. We propose to design a fusion framework that optimally combines information, possibly in a hierarchical way, pertaining to multiple samples and multiple classifiers (algorithms) in order to maximize the performance gain. To facilitate such a framework, we will investigate, in the context of face recognition, the diversity (as well as quality) of information that is desired in the representative face samples (e.g., variations in pose, tilt, lighting, etc.), the nature of the face recognition algorithms to be combined (e.g., PCA, LFA, etc), and a dynamic hierarchical fusion architecture that determines the type of information to be fused as well as the fusion algorithm to be employed based on the available input data. We will also compare the performance gain of intra-modal fusion (e.g., face alone) against inter-modal fusion (e.g., face and fingerprint). This study will benefit dynamic surveillance applications and can be extended to include other modalities as well (such as fingerprints and iris).

CITeR 2005
Research Portfolio

Non-Ideal Iris Recognition: Segmentation and Algorithms

Natalia Schmid (WVU), Stephanie Schuckers (Clarkson), Gamal Fahmy, Xin Li and Lawrence Hornak (WVU)

While current commercial iris recognition systems based on patented algorithms have the potential for high recognition performance, they suffer from the need for a highly constrained subject presentation. This work will explore techniques to adjust to non-ideal images in order to explore methods for iris classification. Non-ideal factors which impact iris recognition include off-angle (horizontal and vertical), noise, rotation, etc. Furthermore, it has been empirically observed that robust segmentation of iris region is the most crucial factor that influences encoding and ultimately the performance of any decision making iris based systems designed thus far for both ideal and non-ideal images. We will explore approaches for robust segmentation.

Multispectral and Multiframe Iris Analysis: Phase I

Lawrence Hornak, Arun Ross and Xin Li (WVU)

Multispectral imaging holds tremendous potential in improving the performance of iris systems while motion characteristics of iris captured by multiple frames are critical to liveness detection. The proposed work has three goals: 1) Enhancement of iris recognition performance through fusion of appropriate spectral band information; 2) Mapping of visible band information to IR enabling the interoperability of IR and visible iris images; and 3) Liveness detection based on detecting signatures such as melanin and elastic deformation of iris. In this initial Phase I study, we propose to experimentally obtain iris images from a collection of representative irises, complete initial analysis of the data, and explore algorithmic approaches in order to address the fundamental need for such a rich set of iris data and determine the merits of further exploration in these three areas.

Cryptographic Protection for Sharable Biometric Test Databases

Bojan Cukic (WVU)

Testing of biometric systems has proven to be a complicated task. Recent studies in CITeR and elsewhere demonstrate that large samples are needed to inspire statistical confidence in the validity and repeatability of biometric tests. As a result, many current projects collect their own datasets for the purpose of validating research results. Biometric data collection is a costly activity. Due to the use of human subjects and privacy concerns, Institutional Review Boards impose strict limitations regarding the ability to share biometrics data.

The goal of this proposal is to develop cryptographic protocols that will provide the necessary levels of confidentiality of biometric test data. In addition to confidentiality, the protocol will ensure non-repudiated access limited to the group of registered biometric database users. Registration procedure and X-509 type public key certificates will be managed using the cryptographic server. The server will also generate symmetric encryption keys for database entries (biometric image and signal files) and user specific

session keys. Key distribution algorithm will ensure that the minimal unit of biometric data sharing can be a single database entry (for example, an image), a subset of entries in a single modality or a multi-modal collection. The last feature of the protocol will be the enforcement of de-identification. The protocol will mask and automatically disallow sharing of humanly identifiable biometric modalities or any other database information that may compromise the privacy of volunteers.

Multi-spectral Fusion for Improved Face Recognition

Besma Abidi and David Page (UTK)

The objective of this project is to develop an optimum fusion-based multi-spectral face recognition system by comparing the performances of various combinations of subsets from a large set of spectral responses using two commercially known FR engines (FaceIt and FaceVACS).

Robust Surveillance System Utilizing 2D Video and 3D Face Models

Anil K. Jain (MSU)

2D face images acquired from static cameras do not contain sufficient information for reliable user identification and difficult in complex environments. We propose to develop (i) a robust face acquisition system at a distance (>30 ft.) using a live video obtained from pan-tilt-zoom cameras, (ii) a face recognition system for the surveillance applications utilizing video and 3D face models, and (iii) a framework to integrate identity evidence with tracking cues (e.g., color and texture) to monitor subjects in challenging environments. The difficulties of user identification in surveillance applications with low quality face images will be overcome by utilizing rich information contained in videos and pose and lighting invariant 3D face models as well as the integration of identity evidence and tracking cues.

MUBI: Continued Development of a Multibiometric Performance Prediction Tool

Arun Ross and Bojan Cukic (WVU)

Multimodal and multibiometric techniques are migrating into mainstream applications. Many different decision level and score level fusion techniques have been described in the literature. But, when it comes to determining the performance benefits of a multimodal approach to specific application, system designers do not have the tools to evaluate and compare different fusion algorithms. An earlier CITeR project developed MUBI, an open source freely available software tool for performance evaluation of decision level fusion of multimodal and multibiometric systems. The only inputs that MUBI requires are the sets of genuine/impostor scores of biometric devices that are considered for system integration. We propose extending MUBI to include several major algorithms for score level fusion. This expansion will require a significant level of redesign of the existing tool. But the benefits of having such a tool clearly outweigh the cost of its development.

Generation of Synthetic Irises

Natalia Schmid, Arun Ross, Bojan Cukic (WVU) and Harshinder Singh, Dept. of Statistic (WVU)

Iris based identification gained considerable attention from the research community in parallel with its public acceptance. A number of iris recognition algorithms have been developed over the past few years. While most iris recognition systems demonstrate

outstanding recognition performance when tested on databases of small or medium size, their performance cannot be guaranteed for large scale datasets (order of a few million). The largest database reported thus far consists of 350,000 iris images. In addition, large scale databases are private and thus are not accessible for the research community. As an alternative to physically collected database of iris images we propose to generate a large scale database of synthetic irises using nonparametric Markov Random Field (MRF). MRF is a leading method used in the field of texture synthesis and analysis [1]. Iris is rich in texture. The challenge lies in generating physically feasible irises. This problem can be reduced to generation of two or three different texture patterns for iris and solving boundary problem to unify (we say "stitch") them. Together with designing a tool that is capable of generating a large scale database of irises, we propose to perform the following three complementary studies. (1) Synthesizing occluded parts of iris images (interpolation). (2) Generating iris images from "partial iris," randomly located patches of a small size on iris image, (extrapolation). (3) Interpolation of low resolution iris image into a higher resolution image using texture synthesis techniques based on MRF. Performance measures will be developed to evaluate the results of these tasks.

Interoperability, Performance, and Fusion Issues in Fingerprint Sensors

Stephanie Schuckers, Sunil Kumar (Clarkson) and Arun Ross (WVU)

The problem of cross-sensor matching has received limited attention in the literature. Furthermore, little work has been performed to allow comparisons of sensors independent of the underlying algorithm. The goal of this research is to assess and develop techniques to facilitate fingerprint sensor interoperability and to design methods to quantify sensor performance. The following issues will be investigated. (i) Enumerate and study the factors that impede fingerprint sensor interoperability; (ii) Design an image quality metric (independent of sensors), that is correlated with performance; (iii) Develop methods to compare sensor performance considering image quality, interoperability, and identified factors including choice of sensor during enrollment; (iv) Devise sensor fusion schemes to increase population coverage, enhance interoperability and improve matching performance. (v) Develop fingerprint representation and matching schemes that would permit interoperability without compromising on performance.

Robust 3-D Face

Anil K. Jain (MSU)

Limitations of 2D face recognition systems are now well-known. These include difficulties with changes in lighting, pose and expression. This has motivated research on 3D face recognition. Our prototype 3D face recognition system (that combines 2D appearance and 3D surface information) achieves 98% accuracy (with 3D models of 100 subjects and ~ 600 test scans) in the presence of pose and lighting variations. But, the performance drops to 91% in the presence of changes in expression. In this project we propose to estimate the non-linear deformation in the facial surface that is introduced due to various expression changes to make the 3D face recognitions systems more robust.

CITeR 2004
Research Portfolio

Developing the PRESS - Methodologies for Estimating Error Rates of Biometric Devices

Michael Schuckers (St. Lawrence University)

The next phase of research on the Program for Rate Estimation and Statistical Summaries (PRESS) will add capabilities to plot ROC curves (both on the original scale and on the log scale), to determine the appropriateness of the Beta-binomial distribution for a given data set, and to estimate the EER. In addition, we plan to do an algorithmic analysis of the software in order to make PRESS more efficient.

Scaling Analysis of Iris Codes using Large Deviations Approach

Natalia Schmid and Bojan Cukic (WVU)

This project explores the scaling and prediction of the capacity of iris biometric systems. We plan to apply the large deviations approach to asymptotically predict the performance of these biometric systems and use the derived results to evaluate performance limits of large-scale identification systems based on iris.

Multibiometric Fusion at the Feature Extraction Level and Face Indexing

Arun Ross and Natalia Schmid (WVU)

This project will develop techniques to perform multibiometric fusion at the feature extraction level. If necessary, feature selection methods will be used to reduce the dimension of the fused feature set. We will also develop an efficient face-indexing (classification) scheme that will rely on the geometric attributes of the human face to narrow the search to a limited number of faces (classes) in the database.

Strategic Business Directions in Biometrics: Research with Vendors, Government and Corporate Buyers

Virginia Kleist and Richard Riley (WVU)

This proposed research will design, plot, and collect a large scale data set related to strategic business issues in the biometrics industry. We will develop an in-depth research tool aimed at surveying perceptions, best practices, and directions from biometric vendors, government, and private buyers. The results should provide a detailed understanding of potential risks and solutions for vendors, government buyers and other users.

Acquisition and Understanding of Nonideal Iris Imagery

Lawrence Hornak, Xin Li, Gamal Fahmy, Natalia Schmid (WVU), Stephanie Schuckers (Clarkson) and A. Realini (WVU Eye Center)

This work will revisit the fundamental information content in the iris and its variability in order to explore means of iris classification and matching through nonideal iris imagery. Automated location of nonideally oriented irises in facial images will be investigated and achievement of imagery of the prescribed quality from lower quality video frame sequences will be explored using deblurring and super resolution techniques.

Utilizing Soft Biometric Traits for User Recognition

Anil K. Jain and Sarat C. Dass (MSU)

The performance of a biometric system can be improved by utilizing ancillary information about the users such as their height, weight, age, gender, ethnicity, and eye color, referred to as *soft biometric traits*. We will (i) design a prototype recognition system that automatically extracts these soft biometric traits along with the primary biometric (e.g., fingerprint), (ii) develop a mathematical framework for integrating the soft biometric information with the primary biometric system for improving the recognition accuracy, and (iii) derive variable weights for the soft biometric traits based on their distinctiveness and permanence. Initial experiments show that the use of additional user information like gender, ethnicity, and height improves the recognition performance of a fingerprint system by ≈ 5%.

Face Image Quality Assessment System

Gamal Fahmy, Hany Ammar (WVU) and Abdel-Mottaleb (U of M)

Poor imaging from biometric systems contribute to the difficulty in detecting features from the image or due to the poor quality of the detected features. While fingerprint identification systems overcome this problem by passing the finger print through a quality assessment stage, there are no such techniques for assessing the quality of images for face recognition to determine weather the image is suitable for recognition or not. In this project we develop a prototype that automatically measures the quality of face images for most well known face recognition algorithms.

On the Independence of Biometric Modalities

Arun Ross (WVU) and Anil K. Jain (MSU)

We investigate the degree of correlation between multiple traits in a multibiometric system. It is generally agreed that the performance gain in a multiple classifier system (MCS) is directly related to the extent of independence between constituent classifiers. However, in the context of multibiometrics, no systematic study has been conducted to ascertain the common assumption of independence between multiple modalities. The goal of this project is to develop a framework to conduct such a study and to derive the degree of dependence between various biometric modalities.

Geometric Coding and Processing of Biometric Images (Phase II)

Xin Li (WVU)

The objective of this project is to continue our investigation of geometric coding and processing of biometric images and demonstrate the potential of signal processing techniques for improving the performance and ergonomics of biometric systems. The research plan for phase II shifts from a single copy case to multi-copy case, i.e., how to exploit the concept of *diversity* to improve the coding efficiency and subjective quality of biometric images. Specifically, our study consists of two parts: image registration, which addresses the problem of resolving the geometric relationship among multiple copies and image manipulation, which intelligently processes the image information base on the discovered geometric relationship.

CITeR 2003
Research Portfolio

Multibiometric Score Normalization
Arun Ross (WVU) and Anil K. Jain (MSU)
The efforts will: (i) systematically study of the role of score normalization in multimodal matching performance, (ii) developing robust and efficient score normalization techniques and (iii) explore automatic template selection and update using clustering principles.

Solidifying CITeR's Liveness Core Competency*Stephanie Schuckers (Clarkson & WVU), Lawrence Hornak (WVU) and T. Norman (Orthopedics WVU)*
A unique specialized capability and skill set for performing spoofing, cadaver, and liveness testing and detection research has been developed. This project will build this capability; establish a broad-based fingerprint liveness testing resource for members and the biometrics community, and advance liveness performance and research in select biometrics.

Multimodal Biometric Systems: Phase II
Anil K. Jain (MSU)
Three different issues in designing a multimodal biometric system are investigated: (i) combine face and iris biometrics to reduce failure to enroll rate and decrease FRR, (ii) combine multiple face recognition approaches to improve the face recognition performance, and (iii) operate a multibiometric system in an identification (cascade) mode.

Biometrics Business Case Study
Virginia Kleist and Richard Riley, Dept of Management, Man. Inf. Systems (WVU)
This proposed research applies prior work in information technology to the specific problem of measuring the cost benefit payoffs from specific biometric technologies. We will link three business issues (measuring the impact of information technology, the performance aspects of expenditures on technology and the specific return on IT investment at the strategic level) to the business case for biometrics investment.

Geometric Coding of Biometric Images
Xin Li (WVU)
The objective of this project is to develop new geometric coding and processing algorithms for biometric images (e.g. fingerprint, face, and iris), which will improve the matching performance of existing verification/recognition systems.

A Study of Various Methodologies for Error Estimation in Biometric Systems

Michael Schuckers (St. Lawrence University)

Several methods for estimating false accept and false reject rates have been developed and recognized for their potential. Doddington's Rule of 30, Schuckers' Beta-binomial approach and the subset bootstrap create inferential intervals that allow the consumer to assess plausible values for the error rate of interest. The goal of this proposal is to compare the quality of estimation for each of these methods against identical data.

Socio-Legal Assessment Study

Lisa Nelson (Pitt)

The proposed study is designed to set the groundwork for the generation of social scientific data on perceptions of biometrics and privacy in divergent settings as well as on the policy impact of biometric privacy legislation on consumer confidence and on the implementation of biometric technology.

Statistical Basis of Multimodal Systems

Bojan Cukic and Harshinder Singh (WVU)

This work seeks to provide a clear analytical justification for multi-biometrics. Recently, Jain proposed the methodology to select weighting system that increases the probability of correct identification. We seek to generalize and extend this result based on the distributions describing genuine and imposter population.

CITeR 2002
Inaugural Research Portfolio

Study of Liveness Detection for Biometric Devices

Stephanie Schuckers, Lawrence Hornak and Timothy Norman Orthopedics (WVU)

This research investigates determining liveness directly from COTs biometric sensor signals. Previous work performed liveness detection through quantification of the temporal finger perspiration pattern. In this work we (1) Select and secure a broad range of biometric fingerprint systems for liveness testing with IAB input, (2) Undertake liveness/spoof test, explore available physiological info, evaluate algorithmic approaches, and (3) Undertake further study of the perspiration algorithm on fingerprint devices.

Multimodal Biometric System

Anil K. Jain (MSU)

The objective of this project is to design a robust multimodal biometric system that uses a combination of features from fingerprint, hand geometry and face. Data corresponding to three biometric indicators- fingerprint, hand geometry and face - will be collected from a number of subjects. Images pertaining to each modality will be processed to extract a feature vector. The techniques developed in this project will be used to optimally combine the information acquired from these three modalities in order to verify a subject's claimed identity. The False Reject Rate (FRR) and False Accept Rate (FAR) will be used to evaluate the performance of the system.

Estimation Study

Michael Schuckers (WVU) and James Wayman (San Jose State University)

The goal of this study is to develop methodologies to estimate the variability in false match and false non-match rates for biometric testing. Several methodologies are under development by the participants of this project to develop techniques for estimating false match and false non-match rates. This study continues and combines the work that has been done independently. Specifically, we convert the work that has been done into an appropriate methodology for sample size calculation.

Template Aging Study

Michael Schuckers (WVU) and James Wayman (San Jose State University)

The goal of this study is to follow a group of individuals repeatedly over time to determine how large an effect there is due to the aging of templates. This test will be done for a variety of modalities based on IAB input. A general statistical framework to begin to model and understand template aging is sought.

Issues in Large Scale Biometric Authentication Infrastructure

Bojan Cukic (WVU)

Biometric technologies can improve the overall assurance of an information system by incorporating the uniqueness of personal biometric signatures into the security and safety management. The downside of using biometric signature is the problem of scalability. Digital biometric identifiers present at (transferred to) multiple sites can be intercepted, pooled, analyzed and, generally, misused. We will investigate system design principles that minimize these downsides of biometric technology-based authentication protocols.