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Analysis of Near-Infrared Phase Effects on Biometric Iris Data

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ANALYSIS OF NEAR INFRARED PHASE EFFECTS

ON BIOMETRIC IRIS DATA

by

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A thesis submitted to the faculty of

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vote has been found to be satisfactory.

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ABSTRACT

ANALYSIS OF NEAR INFRARED PHASE EFFECTS

ON BIOMETRIC IRIS DATA

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Department of Information Technology

Master of Science

The purpose of this research is to ascertain potential iris scan data variations from near infrared waves derived from fluorescent illumination. Prior studies of iris data variances from infrared wave interference of halogen, incandescent, and sunlight with iris cameras suggest that similar changes may exist under near infrared wavelengths from fluorescent light. The concern is that the fluorescent energy emission may interfere with the near infrared detection of an iris camera. An iris camera is used to measure human eye characteristics known as biometrics. If such infrared emission is statistically significant, then it can alter the validity of the iris scan data. The experiment utilized nine hundred forty-five (945) scans from sixty-three (63) subjects. Measured results showed increased heat from ambient fluorescent illumination does not statistically alter the biometric readings of human eyes. The test results fail to reject that data loss will not occur as heat is increased in the ambient fluorescent light source.

ACKNOWLEDGMENTS

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1 INTRODUCTION

Potential iris scan failures from near infrared waves from fluorescent illumination have caused image distortion and data loss. The background, problem statement, methodology, and analysis of iris image capture and iris code corruption in the biometric security model are studied to determine potential implementation parameters and limitations.

1.1 Background

A scanned output may be delineated as a bit stream of ones and zeros that may be used to define the unique characteristics of an individual's iris, also called an iris code. This binary code is ultimately determined by the physical design of the iris, which is the colorfully designed muscle encircling the hole in the center of the eye known as the pupil. Furthermore, through genetics each iris develops its own ligaments, furrows, ridges, crypts, rings, coronas, freckles, and zigzag collarettes. The color of the iris is resolved in the anterior layer of the iris allowing for long wavelengths to be absorbed while shorter wavelengths are reflected and refracted by the cornea and stroma (Daugman, 2001, pg. 1737).

The iris begins to develop during the third month of gestation and those genetic patterns of design develop during the eighth month. During the development phase each iris retains characteristics of its own identity separate and distinct from the other iris as
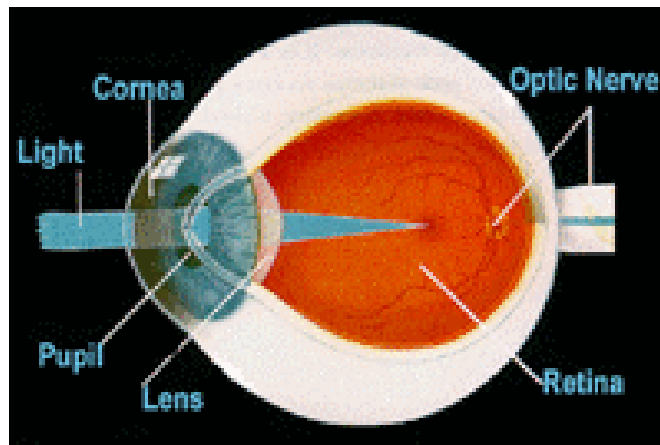
Figure 1–1 Light Absorption

well as from other people. This uniqueness is based on the randomness of iris designs between each eye of one person as well as the eyes of another individual (Daugman, 2001, pg 1). Figure 1-1 illustrates the absorption of light while the pupil allows light to the back of the eye known as the retina. Even those individuals of different genders demonstrate statistical randomness as found in research at Orebro University in Sweden, which states, "There were no qualitative genetic differences between males and females (Larsson, Pedersen, Stattin, 2003, pg. 195)." The differences of irises were identified through visual recognition either at social gatherings or at entrances of organizations.

The evolution of visual identification and authentication of people were common biometric techniques until the technology evolved to digital format. As identification and authentication continued to require a higher degree of secured permissions, using the

proper type of light as well as a proper amount of light became a critical issue to more accurately identify images.

As each area of the iris image is projected, the Cartesian coordinate system representing the return vector values of real and imaginary numbers are shown or registered as a '1'or a '0' in Figure 1-2. Quadrant one (top right) returns a 1 and 1 (1,1), quadrant II (top left) returns a 0 and 1 (0,1), quadrant III (bottom left) returns 0 and 0 (0,0), and quadrant IV (bottom right) returns a 1 and a 0 (1,0). This is repeated 1,024 times until 2,048 bits are extracted equating to a 256-byte bit stream (Daugman, 2004, p. 3). This bit stream is the parameter that constitutes the 'iris code.'
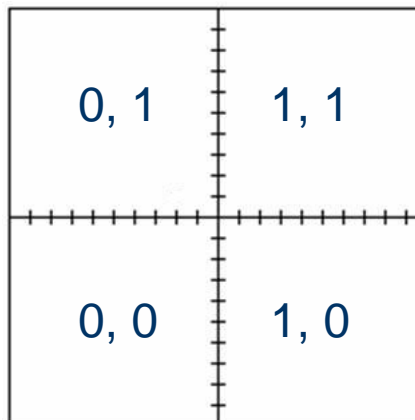
Figure 1–2 Cartesian Coordinates

The 'iris code' algorithm used by the Panasonic BM-ET300 iris camera, a limited indoor monochromatic charged-coupled device (CCD), was implemented within this study to evaluate bit stream variations from image distortion. The BM-ET 300 iris camera has shown the ability to function between 770 nm and 850 nm wavelengths with minimal image distortion from ambient lighting (Meyerhoff, 2005). Sunlight, incandescent light,

and halogen light were known to emit near infrared wavelengths, which caused phase errors and data loss. Phase errors occur when a wave from one direction intersects a wave from the opposite direction. The space between waves causes image distortion and bit stream variation, or data loss. Figure 1-3 below illustrates phase errors from crossing wavelengths of the iris camera and the fluorescent lamp. Ultimately, the iris images may not be captured at a high quality because of phase errors, or wave distortion, of near infrared between devices creating iris codes that may vary in statistical differentiation from the original iris code template, also known as the hamming distance.

The statistical variation is a common occurrence in most biometric security devices such as fingerprint, facial, retinal, and iris scanning currently challenge environmental externalities during enrollment, storage, and recognition of individual characteristics. Of all biometric security devices iris-scanning technology has continued

Fluorescent Lamp ——————————————————→   Iris Camera
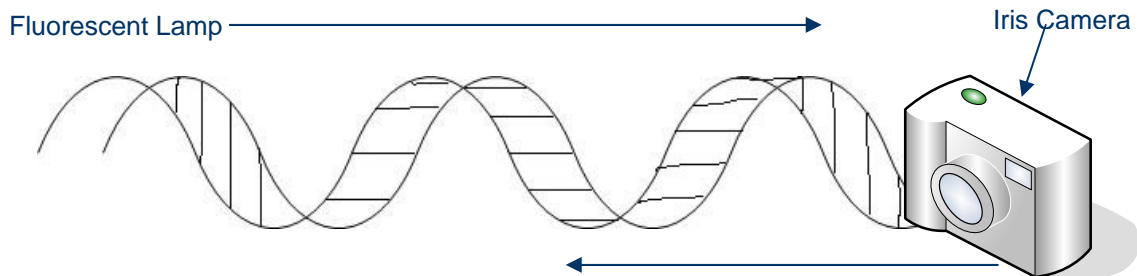
Figure 1–3 Phase Errors

to demonstrate accurate and non-obtrusive measures for most high security purposes. Although, a couple of variables that were responsible for concerns with iris image capture included phase errors as well as improper user interaction. Human interaction mistakes suggested that incorrect subject use of the biometric iris camera caused image errors.

Biometric iris technology showed that phase errors affecting those few failures of the overall need to be chronicled in research enrollment and recognition.

During the enrollment and recognition process, Panasonic Corporation stated that errors from the near infrared spectrum of the sun, incandescent, and halogen lighting interfered with iris cameras that emitted near infrared light, such as the Panasonic BM-ET300 (Panasonic, 2004, BMET 300 User manual, pg. 2). Since fluorescent ballasts generated ambient light from glowing elements, the near infrared wavelengths from heat were produced by the mercury and argon elements (Kataoka and Atagi, 1997, pg. 243). These environmental variables affected the image quality and ultimately the reading of the iris code during authentication and identification. These types of interference have caused corruption of the bit stream code that determined the iris scan.

Further errors were illustrated during biometric fingerprint research at Brigham Young University (BYU). The researchers determined that a lack of subject training of biometric devices created an environment where individuals were deterred from effectively interacting with biometric devices. The lack of device understanding ultimately affected the performance of the system potentially resulting in a negative inference (Green, 2004, Chapter 1).

The Panasonic BM-ET300 iris camera, an indoor monochromatic charged-coupled device (CCD), has the ability to interact with humans at the near infrared wavelengths between 770 nm and 850 nm range (Meyerhoff, 2005). The accuracy and convenience of the technology has worldwide applicability at airports, border crossings, and other high security buildings. Furthermore, sunlight, incandescent light, and halogen light are common in emitting near infrared wavelengths. The iris images may not be

captured at a high quality because of the phase errors, or wave distortion of the reflected image, between devices creating iris codes that vary in statistical differentiation from the original iris code template, also known as the hamming distance. The background light sources emitted limited near infrared to prevent interference with the iris camera during the recognition process.

During the process of recognition, a statistical analysis was performed to determine the failure of a test of statistical independence, meaning a similarity between the two different irises did not exist. This failure of statistical independence (p =. 01) was guaranteed to pass every time for different irises since the degrees of freedom, or forms of variations in the iris, were compared… approximately 249 degrees of freedom (Daugman, 2004, pp. 3-6). The bit stream of the enrolled iris and the bit stream of the recognized iris were applied by the use of the Boolean Exclusive-OR operator (XOR). The XOR operator is used in this instance to determine discrepancies between any corresponding vector values of zero (0) and one (1). The dissimilarity between the two iris code bit streams is quantified in an error transmission term called Hamming Distance (HD). The expected difference between two iris codes is expected to be 0.5, or a 50/50 chance, which is not enough to show similarity. As the fraction, or Hamming Distance, comes closer to 0, then it is implied that it is extremely improbable for two different irises to disagree in phase information, or bit stream sequencing (Daugman, 2004, pp. 3-6).

1.2 Problem Statement

Technically, the problem occurs when different infrared wavelengths in fluorescent illumination changed the captured biometric parameters, which uniquely described a given human iris. The iris image characteristics, when captured with no

external infrared lighting conditions, created a complete binary code template. When captured at a subsequent recognition event with higher infrared wavelengths from fluorescent illumination, the binary code differentiated from the original template. The resulting algorithm continued to follow a cyclic process of scanning the iris in 0.15 mm to 1.2 mm ranges to generate a bit stream representing the angle information of quadrature wavelets. The angle information, also known as phase vectors (quadrant I, II, III, IV), is used to assign pair bit values of a zero or a one, ultimately deriving a 256 bit stream (Daugman, 2004, p. 3). Phase errors created from parallel phasing of infrared waves from the fluorescent illumination with the infrared wavelengths of the BM-ET300 iris camera generated a different bit sequence. Ultimately, fluctuating iris codes caused false acceptance or rejection readings from an iris image.

1.3 Hypothesis

As infrared wave frequencies increase (0 nm, intensity $= 0 > x < 820$ nm) in a fluorescent light source, the digital iris image will remain unaffected.

1.4 Justification

Studies in the area of iris camera technology from John Daugman of the University of Cambridge suggested that further research was needed in the environment of iris image capture (Daugman, 2001, p. 12). The need for reliable and accurate iris scans while using fluorescent illumination is the motivation for the research. When the accuracy of an iris scanner is not sufficient for an operational environment, implementation of the device is in question. The question of what fluorescent lighting is required to achieve a given level of performance remains to be clearly answered. A

model that describes fluorescent illumination performance can provide information about potential illumination options for implementation. The results of this research will include a descriptive performance analysis of iris scanning within a fluorescent illumination as the background light source. This model will address the viability of using fluorescent illumination to achieve high accuracy iris scanning.

1.5   Thesis Structure

The structure contains the Review of Literature, Methodology, Summary, and Conclusions. The Review of Literature establishes a working knowledge of the problem statement, the Methodology outlines the process and procedures to replicate the study, and the Summary organizes the data to be interpolated and the Conclusion analysis the data and presents further research from this study.

1.5.1   Review of Literature

The research presented began with a review of literature used to establish a working knowledge of biometric technology. Furthermore, the study has served to develop eye technology as a highly accurate and stable means of identification and authentication.   The review continued its focus on iris technology including external infrared wave interaction with infrared on iris cameras and on human subjects. Iris standards will be presented in coordination with technical implementation, including associations and issues with other biometric technologies. For the purpose of this project, security concerns with iris scanning technology are observed as implied as a function of near infrared wave interference.

1.5.2   Methodology

This methodology developed the procedural requirements of the research method associated with the problem statement. Additionally, an outline of the process was devised to implement a repeatable process. The theoretical approach of the research method was reviewed and analyzed to normalize the iris data. This methodology covered the five main areas of this research, namely: (1) determining technical as well as logical requirements, (2) standardizing practices and procedures, (3) controlling constants and variables, (4) obtaining human testing permission and subjects, and (5) analyzing statistical results for feasibility analysis of identity management technology used within environments demanding high security. The research method continued to normalize the statistical results and establish a current baseline to determine further research.

1.5.3   Summary

The summary is a report of details and results of the all of the test scan performed. Analyses of the results in coordination with the thesis research problem are presented and meanings are interpreted through discussion. Final conclusions in this chapter are presented to expand the reasoning and derivation of the compiled and separate results.

1.5.4   Conclusion

Following the summary, conclusions are extrapolated and continual research methods are presented. The results will develop a benchmark to continue potential research of iris data variances. This portion contains writing on further areas of study in the field of iris technology development as well as subject interaction with current and future iris technology.

1.6   Assumptions

The purpose of scanning each subject is to understand the importance of image corruption during the process of capturing iris characteristics. Pederson and Stattin (2003) of Orebro University in Sweden discussed that if not closely looked into, the iris may be construed as the same from the left to the right eye as well as the same from one person to another person. The relationship between irises of one person is called intra-correlation; inter-correlation is the relationship between an eye of one person and an eye of another person. The assumption statistically suggests that scanning similar people of gender, race, or nationality would create reliable results similar to scanning subjects of diverse gender, race, or nationality (Larsson, Pedersen, Stattin, Pg. 195, 2003). Therefore, the data may be limited for collection from any person that may be solicited within the university setting.

Image and data corruption through illumination would provide valuable information for manufacturers as well as researchers in showing false positive or false negative results. The iris capturing quantifies the effectiveness of fluorescent illumination and indicates whether or not it was an effective means of illumination for the Panasonic BM-ET300 iris camera. Furthermore, the results of the study could be applied to Information Technology professionals implementing an iris biometric system. Panasonic could use these results to continue develop iris cameras to function in all illuminations levels of a given lighted room.

1.7   Delimitations

The following conditions are variables and were not statistically evaluated as significant factors:

1. The sample size was limited to a university population. The research being performed on a campus would not statistically be affected by changing background light.

2. The university population is considered suitable for collection of the nine hundred fifty-four (954) iris sample sizes. Eight hundred eighty-two (882) samples are evaluated after outliers are removed from the sample.

3. Diversity of nationality, gender, and race are not necessary in conducting thorough data collection of iris samples.

4. Reflection and refraction are elements of ambient surfaces and are part of the iris camera readings.

5. Variables such as eyelash interference, eye dilation, and nationality are accounted for in the algorithm of the BM-ET300 software.

1.8　Glossary of Terms

Biometrics: method of verifying an individual's identity based on measurement of the individual's physical feature(s) or repeatable actions where those features and/or actions are both unique to that individual and measurable.

FAR (False Acceptance Rate): measure of the likelihood that the biometric security system will incorrectly accept an access attempt by an unauthorized user

FRR (False Rejection Rate): measure of the likelihood that the biometric security system will incorrectly reject an access attempt by an authorized user

Failure to Enroll (FTE): the rate at which scans fail to enroll into a system database

BM-ET300 Iris Camera (Charged-Couple Device - CCD): small electronic camera made out of a semiconductor material for storing electronic information

Hamming Distance: percentage of bits different from enrollment and identification

Iris: muscular diaphragm that controls the size of the pupil; it forms the colored portion of the eye

Authentication: process of determining whether someone or something is, in fact, who or what it is declared to be

Integrity: assurance that data has been sent by the original person

Identification: process of recognizing something or someone by remembering

Confidentiality: Assurance that the data has not been viewed by anyone other than the person receiving it

Illumination: degree of visibility of the environment

Intensity = number of waves (counts)

Near-infrared (NIR): infrared part of the electromagnetic spectrum nearer to the visible portion; wave frequencies from 700 nm to 1000 nm

Statistical Significance: probably true (not due to chance)

Wavelength (Lambda -Λ) = frequency of electromagnetic wave

2 REVIEW OF LITERATURE

The review of literature presents six developing positions found in literature to substantiate the research problem. Furthermore, the published literature develops a potential for interference existing between near infrared emitting devices. The reviewed positions include the (1) biometric security and technology models, (2) iris technology and retinal technology, (3) security and legal issues, (4) infrared and eyes, (5) infrared and cameras, and (6) iris recognition standards. The study continues to present instructive segments of biometric eye technology, the prior research of the problem, and observations of ongoing research.

2.1 Biometric Security Model

Biometric security models are logical systems that provide architectures, policies, and procedures that develop a sense of confidentiality, integrity, availability, and non-repudiation (Panko, 2004, pg. 256). Biometrics, or the 'measurement of life,' is a means to identify people and ultimately to authenticate the person's claimed rights to gain access within a particular security model. The use of biometrics for information assurance does not always guarantee full identity protection, but does provide an assertion at a reasonable degree that the people who access, originate, send, or alter information on a system are who they claim to be (authentication), have the authority to

do whatever they are doing (authorization), and cannot avoid accountability for what they are doing (non-repudiation).

Research at the University of Purdue suggests that a multidimensional model of biometric security called 'Biometric Architecture and System Security' (BASS) provides a level of security that will protect a networked organization (Leniski, Skinner, McGann, Elliott, 2003, pg. 444). The model follows a system of checks and balances to ensure an accurate decision upon completion of the process. Accordingly, the general biometric security model relies on four sequential elements of assurance for accurate identification and authentication.

The sequential process is listed below:

1. Data Collection

2. Transmission

3. Signal-Processing Subsystem

    a. Feature extraction

    b. Quality control

    c. Pattern matching

4. Decision Subsystem

2.1.1   Data Collection

The data collection process receives the behavioral and physiological characteristics of the scanned subject. These unique metrics are stored for future retrieval of identification and authentication. This first step becomes critical resulting in data that will either become a template, or the data will be measured for uniqueness against the template. Changing background light is an ongoing issue during the time period data is

collected. Following procedures to ensure control of the light is needed to ensure reliable data.

Because of the changing background illumination variables, 'best practices' are important for network administrators. The administrators must adhere to a system of policies to act or react to security attacks to biometric devices. Daugman (2004) suggests that the 'best practice' is to have 'Liveness Detection' in iris recognition devices. Due diligence, or the process of arriving at a solution, is critical at the moment of data collection process in order to avoid unsecured or unauthenticated attacks (QinetiQ, 2004, pg. 7). Following these best practices provides a standardized mean to yielding similar biometrics parameters. Although procedures ensure the process is the same, the changing environment is difficult to control.

The probability that two biometric measurements yield the same biometric parameters as a true positive is highly unlikely due to variable background light. Since the surrounding environment of the device is always changing, the results may deviate each time a reading is taken (QinetiQ, 2004, pg. 3). These changing environmental variables include heat (infrared light), visible light, and humidity. In order to fully utilize the power of biometric measurement devices, complete understanding of the surroundings is required for proper installation and use. Likewise, subject interaction may affect the outcome of the scan from improper movements as well as changes in their biological features (i.e. new glasses, disease, or eye damage) (Ackerson, 2006, pg. 1).

2.1.2 Data Transmission

Transmissions of iris data within some systems require the Internet for storage, while others store straight to the hard disk drive. Ultimately, the transmission of iris data

is determined by the size of the system. This size element will then determine types of data compression and packet structuring. The actual iris code, which can vary from 256 bytes to 512 bytes, is stored within the BM-ET300 iris camera and is only accessed from a reference in the database (QinetiQ, 2004, pg. 5). The header, image, 'Yes' or 'No' decisions, and footers are the payloads for any iris data transmission.

When iris data is sent over the wires it follows normal protocols for the network. The data presented in this research is performed over Ethernet and required network protocols to ensure the data is correctly transmitted between device and server. Ethereal data capture software illustrates the protocols used for transmission as seen in Figure 2-1. The Ethernet connection between the device and the camera are set using TCP at 8030 and 1084. Such ports may be scanned, yet the iris code is never transferred over the Ethernet connection and therefore, the iris camera must be hacked before the enrolled subject's identity can be captured.

2.1.3   Signal Processing

Signal processing provides the unique features of the subject pattern matching and overall quality control to the processing server. The dispensation of the signals requires logical hamming distance analysis to determine any variances among the bit string. Complete control of bit sequencing is needed to maintain authentic bit sequencing. The Hamming Distance, or the fraction of bits that differ between two binary strings, provides a probability that the two bit strings are authentic or an imposter. The result of the logical algorithm provides a clear decision of a 'Yes' or 'No' between the bit strings. Bit variations above a 30% hamming distance gives a decided 'Yes,' or '1,' indicating that

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the bit streams are different; otherwise, the decided 'No,' or '0,' is given that the bits are

similar (Daugman, 2000, pg. 2).
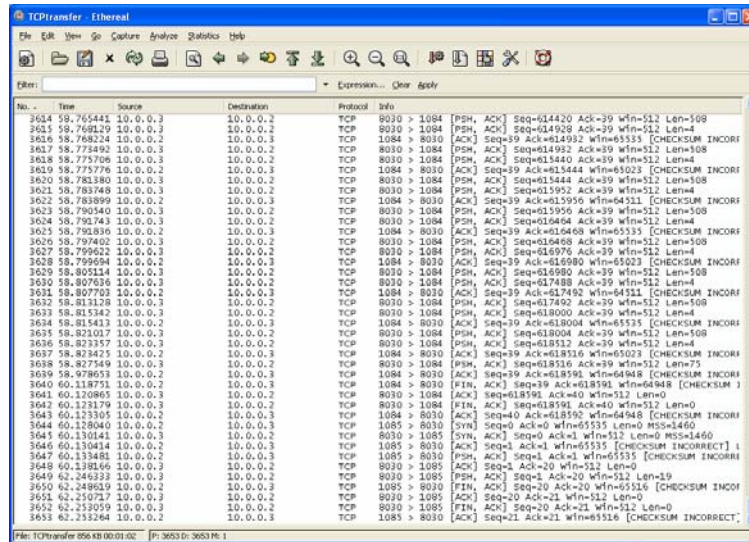
Figure 2–1 Ethereal Packet Capture

2.1.4 Decision Subsystem

The decision subsystem evaluates the returned data and provides a truth table

giving a false accept (FA), correct accept (CA), false reject (FR), or false accept (FA).

Although four possible return values are given, only two actions are taken: (1) accept (FA

& CA), or (2) reject (FR & FA) (Daugman, 2000, pg. 1). These simple truth values will

then tell the system that the next steps are to 'accept' with no further actions; 'reject' and

try over; or 'reject' and no further action (Leniski, Skinner, McGann, Elliott, 2003, pg.

445). Such a truth table provides a logical system for the iris server to provide accurate

processing when the subject is presented.

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2.1.5 Biometric Security Model Summary

The biometric security model is an architecture that provides confidentiality, authentication, availability, and non-repudiation at 1 in 1.5 billion odds of a false match. During the process of the biometric security model, attacks and environmental alterations may affect the odds of a false match within the system. Such variables pose a suggested need for appropriate system design and security architecture to ensure reliability and stability (Tao, 2002, pg. 7).

2.2 Biometric Technology

Biometric recognition is a process that implements the security model of identity collection, storage, and decision-making. The technology provides a reliable and accurate means to facilitate the identification and authentication of subjects to the system. Reviewing Table 2-1 for live biometric methodologies will illustrate a comparative analysis of the most common biometric techniques (Williams, Reich, 2003, pg. 1). Even though the technologies have a high or very high accuracy, the ease of use and the stability are variable; although, the False Acceptance Ratio varies from 'Medium' (1 out of 100 FAR) to 'Very High' (1 out of 1,200,000 FAR).

The stability and accuracy of iris recognition presents itself as a proven method of identification and authentication. The iris is the only internal organ of the human body that may be viewed externally. Furthermore, the iris does not change over time unless disease, injury, or damage occurs (Ackerson, 2006, pg.1).

2.2.1 Fingerprint

Fingerprint recognition is an interesting technique for identification since it is one of the most commonly used biometric methods. Williams and Reich (2003) categorized relative accuracy to other biometric devices in terms of 'Very High (1 out of 1,200,000),' 'High (1 out of 700 - 1000),' 'Medium (1 out of 100),' and 'Low (1 out of 50)' as seen in Table 2-1. Mary Hanson (2000) stated that the accuracy and results of fingerprint scanning requires the experience of an expert in the United States. Other

Table 2-1: Biometric Device Comparison (Williams, Reich, 2003, pg. 1)

Device	Stability	False Acceptance Ratio	Ease
Fingerprint	High	High (1 out of 1,000)	High
Face	Medium	Medium (1 out of 100)	Medium
Retina	High	Very High (1out of 1.2Million)	Low
Hand	Medium	High (1 out of 700)	High
Iris	**High**	**Very High (1out of1.2 Million)**	**Medium**

countries require a minimum, but not in the United States. Fingerprint biometric methods demand physical contact between the biometric device and the subject. Such interactions have developed a sense of insecurity and concern of subjects (Green, 2004, pg. 1).

2.2.2 Facial Recognition

Facial recognition is an emerging technology that has no need for interacting with the subject. The trade-off of 'High' Stability and 'Very High' Accuracy of 1 out of 1,200,000 False Acceptance Ratio (FAR) suggests that biometric camera technology may still be implemented with a 'Medium,' or 1 out of 100 FAR. Furthermore, identification accuracy is 'High' at 1 out of 1000 FAR when the subject has a straight visual of their

face to the camera. If the angle of the image changes, then the stability and Ease of use categories drop below a standard level of implementation. Continual development of this technology reflects the sincere impetus to implement the technology in high traffic environments.

2.2.3 Retinal Scanning

Retinal scanning is just as accurate and stable as iris scanning. Ease of use is low since the subject is required to place their head into a strictly controlled position. The camera takes an image of the back of the retina to map the blood vessels, which do not change overtime (Ackerson, 2006). Implementation of this camera requires professional training by ophthalmologists or optometrists. Using retinal scans; doctors are able to determine disease or injury to the human optical network over time.

2.2.4 Iris Recognition

Iris recognition is a process utilizing two of the functions of information systems, which include subject interaction and information technology. The subject presents their eye to the camera and an image of the iris is captured. Software then executes an algorithm to create a biometric iris code to either become a bit string template, or become a bit string measurement to be compared against a previously captured template. The process is critical in recognizing potential failures to the system and in developing an environment suitable for stability and consistency. The bit stream in Figure 2–2 can easily be changed when an external variable such as infrared light causes different phase bits to be generated to a different resolution, thus abating from the original template image (Daugman, 2004). The process of capturing the features of an iris consists of

algorithmic procedures starting with (1) iris image capturing, (2) iris feature encoding, (3) statistical independence, and (4) 'Yes' or 'No' decision environments (Daugman, 2004, pp. 2-9).

Figure 2–2 Iris Code (Daugman, 2000)

2.2.4.1   Iris Image Capturing

Capturing and recreating the human characteristics of the iris requires a mathematically accepted algorithm. In Figure 2–3 Daugman provides one such algorithm in an Integrodifferential mathematical operator to encompass the eye.

$$\text{Max}_{(r,x0,y0)} \mid G_\sigma(r) * (\partial/\partial r) \int r,x0,y0 \ (I(x,y)/2\pi) \ ds \mid$$

Figure 2–3 Integrodifferential Operators (Daugman, 2001, pg. 7)

The purpose of the operator is to estimate the pupil boundaries, the outer boundary of the iris, and the radius of the iris. Execution of the operator determines the circular edges of the each characteristic of the eye to single pixel exactitude (Daugman, 2004, pg. 2). The captured iris image is organized in a pattern to be parsed by the algorithm, which will then derive the digital iris pattern.

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Daugman (2003) has shown that his iris algorithm is highly accurate in stable environments. External variables, however, such as background color, lighting, noise, and weather are the potential problems for continuing research (Tao, 2002, pg. 7).

2.2.4.2   Iris Feature Encoding

The digital patterns are obtained through a phase-quadrant demodulation using 2D Gabor Wavelets (Daugman, 1985, pg 1160-1169). Gabor wavelets diagram the wavelengths in vectors of a Cartesian plane. Daugman researched the 2D Gabor wavelets back in 1985 and 1988, before iris patterns were of any real significance for security (Daugman, 1985 & 1988, pp. 1160-1169 & pp. 1169-1179). Since then his research has applied the Gabor wavelets to iris patterns. According to Daugman (2001), "Local regions of an iris are projected onto quadrature 2D Gabor wavelets, generating complex-valued coefficients…."

The returning values are real and imaginary representing a zero (0) and a one (1) as represented in black (zero) and white (1) in the upper left hand corner of Figure 2-4 below. Daugam (2004) states further, "The angle of each phasor is quantized to one of the four quadrants, setting two bits of phase information. The process is iterated 1,024 times across the iris until 2,048 phase bits are sequenced making a 256-byte code for each unique iris.

The amplitude of a wavelet is due to extraneous factors such as image contrast, illumination, and camera gain, ultimately causing potential phase errors in differentiating patterns. Furthermore, signal analysis shows the patterns are two-dimensional, and then complete depictions of any image are possible (Lee, 1996, pg. 996). The depictions of

wavelengths are changed when acted on by another wave, often changing the frequency and therefore, the data sequence of the signal.

2.2.4.3   Statistical Independence

Further studies of iris recognition have provided nearly 9.1 million samples for statistical analysis. The iris samples offer assistance in identifying characteristics that affect the uniqueness of each scan. When comparing a set of irises statistical assurance is needed for a 'Yes' or 'No' decision. If two irises are different, then they will statistically pass the test of independence. When they are the same, then they will fail the test of independence, suggesting a hamming distance greater than 30% of the total bit stream (Daugman, 2001, pg. 8).
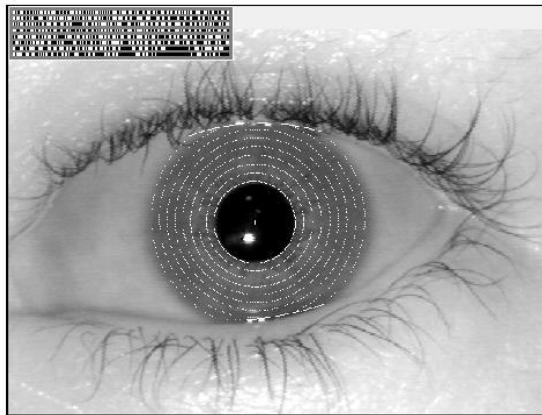
Figure 2–4 Monochromatic Iris and Iris Code at 35cm (Daugman, 2001, pg. 1)

Table 2-2 below illustrates the power of the sample size in determining statistically strong odds of a false match (Daugman, 2001, pg. 9). The probability has a magnitude of a seven-fold increase at the 30% hamming distance indicating that this is a point of statistical significance.

Table 2-2: Hamming Distance and False Match (Daugman, 2001, pg. 9)

HD Criterion	Odds of False Match
.28	1 in 10^{11}
.29	1 in 13 billion
.30	1 in 1.5 billion
.31	1 in 185 million
.32	1 in 26 million

2.2.5 Fingerprint Scanning

Fingerprint technology provides the easiest and most available security applications of all biometric devices. With production increasing each year, implementation becomes feasible to more companies. The algorithmic process is similar to other technologies.

The finger is first placed on a scanner and an American National Standard (ANSI) file format is generated and then placed into an image file. The image format is next set to binary to create differentiation between minutiae points.

Appearing bifurcation, disappearing bifurcation, appearing ridge ending, and disappearing ridge ending may now determine the four areas of a fingerprint minutia (Green, 2005, pg. 54). The technology furthers the biometric paradigm of enrollment and identification and authentication. Hamming Distance decision environment of similar or different iris features.

2.2.6 Biometric System Elements

The algorithm of iris scanning handles the logical side of the biometric system. The process requires three main elements in order for the system to come to a definitive 'Yes' or 'No' decision. Figure 2-5 below illustrates the limits of a definitive 'Yes' or 'No' decision. Some systems require multi-modal authentication such as fingerprint and

Decision Environment for Iris Recognition

same
mean = 0.110
strd.dev. = 0.065

different
mean = 0.458
strd.dev. = 0.0197

2.3 million comparisons

$d' = 7.3$

Density
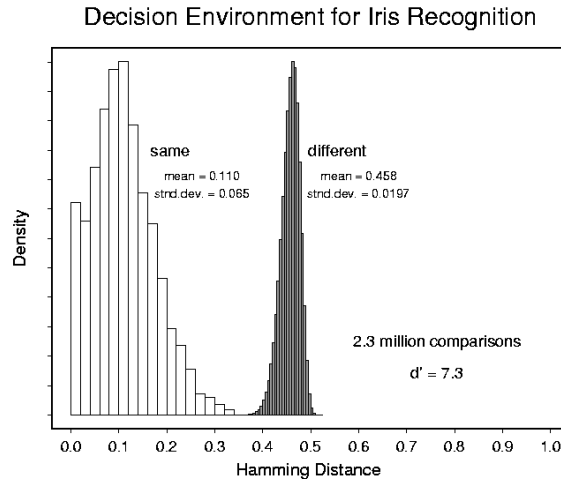
Hamming Distance

Figure 2–5 Hamming Distances (Different / Same) (Daugman, 2001)

hand geometry to ascertain one's identity. Iris scanning provides a definitive result because it represents one's biochemical makeup more accurately than a fingerprint scan. During the identification module subjects presents themselves to the scanner and this will preclude the need to remember anything for authentication. The next three elements establish the framework of a biometric system. These requisites are enrollment, template, and matching.

2.2.6.1   Template Enrollment

Basic enrollment is the process of accumulating all the characteristics of the presented subject and generating a template to be used at a later time. The typical procedure involves the Panasonic BM-ET300 capturing four images during enrollment. This process is the focus of the research in determining how external near infrared light may affect the enrollment process. Furthermore, incorrect subject interaction has been known to be a cause of errors during enrollment of the iris template (Murali, 2004).

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2.2.6.2 Template Creation

Template creation is the process of the iris scanner to produce a bit sequence to store for later matching. The template is stored locally on the device and a reference is placed in the database to access the iris code from the BM-ET300 iris camera. The placement of the 'iris code' on the camera is a means of multi-level security in case the Iris Server is attacked. Proprietary devices, such as the Panasonic BM-ET300 iris camera, are designed so that no one has access to the iris code (Meyerhoff, 2005).

2.2.6.3 Template Matching

The matching process is the comparison of bit streams in iris scanning. The bits run through an algorithm where they are processed through an XOR function. The number of dissimilar bits is compared and a Hamming Distance is calculated. The process returns three potential failure conditions: (1) failure to enroll, (2) false match, (3) false no match. Each one of these will cause the subject to retry the process causing potential frustration and concern for a waste of time (Murali, 2004).

2.2.7 Environmental Influences

External variables that may affect the accuracy and reproducibility of biometric devices are concerns that are constantly being addressed in order to increase the usefulness of the biometric devices. Subject interaction with the device may be altered by variables such as (1) Background color, (2) other faces, (3) lighting, (4) weather, and (5) temperature. Research continues in the subject interaction and mobile iris scanning at Purdue University (Elliot, 2006).

2.2.8   Alternative Iris Recognition Methods

Kang Ryoung Park (2005) of SangMyng University in Korea proposes a fast method of capturing iris images based on narrow-view and wide-view iris cameras. Park (2005) said, "Using the wide-view and narrow-view iris cameras, I also compute the subject's gaze position. This information is used for aligning the X-Y positions of the subject's eye, and I use the visible-light LED for the fake-eye detection algorithm." This method produces an illumination time of 480 milliseconds (ms) as compared to the older technology of 1523 ms (Park, 2005, pg. 1). The Panasonic BM-ET300 currently produces an illumination time of 200 ms during image capture (Panasonic User Manual, 2003, pg. 2). Alternative methods push Panasonic and other corporations to continue developing quick and accurate biometric devices such as the BM-ET300.

2.2.9   Iris Technologies Comparison

The International Biometric Group conducted an "Independent Testing of Iris Recognition Technology" to evaluate major products. Three iris scanners evaluated are: (1) LG IrisAccess 3000, the (2) OKI IRISPASS WG, and the (3) Panasonic BM-ET300 iris camera (IBG, 2005). As seen in Table 2-3, the three scanners are shown with LG IrisAcess and OKI IRISPASS WG performing at a higher FTE than the BM-ET300.

Table 2-3: Scan Comparison between Iris Scanners

Device	FTE	Scans
LG IrisAccess	89.89%	3364
OKI IRISPASS WG	89.68%	3364
BM-ET300	**83.32%**	**3364**

2.3   Iris Technology and Retinal Technology

Iris and retinal scanning are distinctive in practice and use completely different technologies to capture an image of a portion of the eye. Iris scanning utilizes general camera technologies to capture the image. Unlike iris scanning, retinal scanning requires the camera to be about three-quarters of inch from the eye lens (Hill, pg. 11). The technology is considered to be more invasive than iris scanning.

Both of the optical technologies are considered to be the most secure biometric devices. The human eye begins to quickly decay after death and, therefore, is difficult to "fraudulently by-pass the biometric system (Hill, pg. 9)." Figure 2–5 compares the image results of an iris scan and a retina scan. As viewed here, the image of the iris is taken in front of the eye, while the image of the retina is taken in the back of the eye. Additionally, the iris scan takes approximately one minute for full algorithmic processing.

The retinal scan takes about 3-5 minutes for algorithmic processing. If the pupil is not dilating enough, then the full retina may not be completely examined. Eye doctors often dilate the pupil to gain full access to the back of the eye. The time it takes for the pupil to constrict back to normal size is anywhere between 1-3 hours (Ackerson, 2006, pg. 2). Both devices are subject to issues of disease or injury. John Ackerson (2006) said that if a subject presented an injured or diseased eye, then potential for failure increased (Ackerson, 2006). Since subject interaction is more intense than iris scanning it becomes a medium ease of use as viewed in Table 2-1.

2.4 Security and Legal Issues

Daugman (2001) has provided a mathematical algorithm that has shown minimal scan failures showing that it compares with retinal scanning, which is considered the most secure optical method (Hill, 1990, pg.1). Legal legislation of iris scanning has not surfaced an issue since volume identity testing has not been made on the technology.
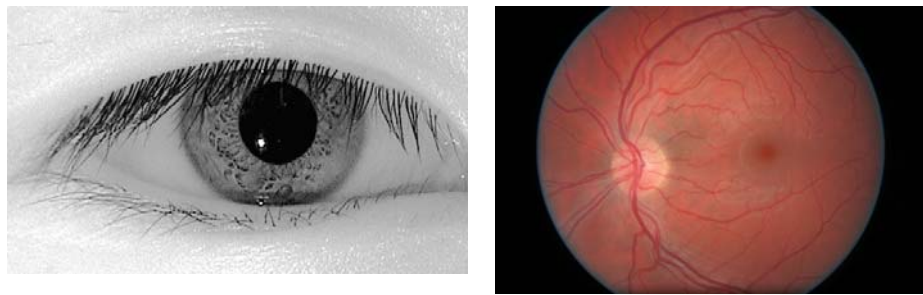
Figure 2–5 Iris (Daugman, 2001, pg. 1) and Retinal Image (Ackerson, 2006)

2.4.1 Security Issues

Iris recognition currently is being used in jails and airports. Since the jails and airports are passing people of different cities, states, and countries the people responsible for security are unable to identify everyone, unless they have the subject's iris template in a database and they can scan and compare them upon arrival. The question follows, when does the enrollment occur for the traveler? This may take considerable time, but with security on the rise since the attacks on the United States on September 11, 2001, efforts to implement such devices are on the rise (economis.com, 2001).

2.4.2   Legal Issues

Forensic scientists are the not interested in the technology as of yet and will not make a push for it until it can be used on tissue that has began decay. Therefore, the public sector has minimal use of it and only wants it for automatic authentication purposes (de Hert, 2005, pg. 6-7). Legal issues would only come to fruition if the technology infringed on fundamental rights, such as physical integrity and rights of privacy. As of now, use of the technology has not triggered a need for legislation (de Hert, 2005, pg. 7).

2.5   Infrared Iris Technology

Infrared is a unique portion of the electromagnetic spectrum that can affect subjects as well as devices that emit similar wavelengths. Infrared effects on human eyes and on iris cameras will be reviewed and discussed in relationship to the research problem. The ability of the human eye to absorb light provides a means to capture the necessary characteristics of a subject's eye through an infrared camera.

2.5.1   Infrared Effects on Eyes

The front structures of the eye may be affected by infrared due to the immediate contact to light. Such structures include the cornea, the aqueous humor, and the iris. The outer region of the human eye absorbs different amounts of infrared at different points of the eye. The ability to present a clear image of the features in the eye is critical during the iris capturing process. As the wavelengths increase, the absorption of eye tissue moves towards the front of the eye. Infrared exposure may cause damage to eye tissue and may change physical features as well as potential iris scan data (Ackerson, 2006). Tissue in

each eye structure absorbs at different wavelengths, which may cause eye damage in the future. The retina absorbs most of the infrared waves between 700 nm and 1000 nm. Between 1000 nm and 1500 nm the lens and vitreous humor absorb most of the infrared. As long as the infrared is not sustained for a long amount of time, then the effects on vision will be minimal (Voke, 1999, pg. 22).

2.5.1.1 Cornea

As the Panasonic BM-ET300 iris camera emits infrared at wavelengths of 800 nm, the cornea threshold for damage is high. Infrared exposure of 800 nm between 1-10 minutes has shown tissue necrosis, or cell death, from 2-7 mm in depth (Journée-De Korver, J.G., Oosterhuis, J.A., Van Best, J.A., and Fakkel, J., 2004). Fortunately, the emission time for the infrared pulse of the Panasonic BM-ET300 is 200 ms (1/300 of 1 minute), which means the cornea can withstand potential long-term necrosis (Panasonic, 2003, pg. 33). The cornea protects the iris and the retina from externalities that may damage the fundamental elements of the eye, ultimately preventing proper vision. The cornea receives no nutrients from blood vessels and repairs itself through tears and the fluid in the aqueous humor (thinkquest.org, 2006).

2.5.1.2 Aqueous Humor

The aqueous humor is similar to water and is not affected by infrared light. According to Voke, any change to the aqueous humor suggests that damage occurs to the lens, the cornea, or the retina (Voke, 1999, pg. 23). Conclusively, damage to the eye is the cause of physical change to the humor (Ackerson, 2006).

2.5.1.3   Iris

The iris absorbs nearly half of all the infrared light between the range of 750 nm and 900 nm, which is the range used by the Panasonic BM-ET300 iris camera (Meyerhoff, 2005). Interestingly, the pigmentation of the eye determines levels of absorption and presenting the necessary features and characteristics to the camera lens. Since the BM-ET300 iris camera emits for only 200 ms, the actual absorption affects the iris and ultimately evolves into necrosis (Voke, 1999, pg. 23).

2.5.2   Infrared Effects on Panasonic BM-ET300 Iris Camera

The emission of heat is a generating force in creating wavelengths called infrared. The wavelength just below visible light, often called near infrared, usually ranges from 780 nm to 900 nm. The range is similar to the Panasonic BM-ET300 iris camera (Meyerhoff, 2003). The camera uses the infrared light, which is just beyond visible light, to prevent light aversion to the subject (usbyte.com, 2006).

2.5.2.1   Infrared-to-Infrared Interference

Near infrared (NIR) light, or heat, have characteristics that merge between visible and the full infrared (IR) spectrum. As the light is projected on the object, it is then illuminated just enough to see monochromatic features. Accordingly, "The amount of light coming to the eye from an object depends on the amount of light striking the surface, and on the proportion of light that is reflected (Adelson, 2000, pg. 1)."

Continued research has shown that interference between different objects such as short-frequency lighting systems and infrared remote controls are caused by frequency similarities, thus leading to phase errors. Furthermore, research from Universidade de

Aveiro in Portugal found that fluorescent lamps produce very strong interference with infrared spectra extending up to the 1000 nm range. The ranges are unique to fluorescent ballasts and iris cameras emitting infrared pulses between 780 nm and 900 nm (Universidade de Aveiro, 2005). The reflected eye image develops a phase error with the emitted infrared light from the fluorescent ballast and changes the picture as well as the iris code between enrollment and authentication (Kwok-tin, 2003, pg. 1). Panasonic shows that this distortion is unique to infrared, which is found in incandescent light, halogen light, and sun light (Panasonic, 2003, pg. 16).

2.5.2.2   Infrared-to-Camera Interference

The frequency mixing with infrared light from fluorescent ballasts introduce phase errors in iris recognition. Shozo Kataoka and Kaoru Atagi state, "Results gained by more accurate analysis show that there is indeed a small quantity of infrared being generated in the fluorescent lamp (Kataoka, Atagi, 1997, pg. 1)." They found that infrared is prevalent from 780 nm all the way to 1050 nm, more than enough to encompass the range of the Panasonic BM-ET300 iris camera. National Electrical Manufacturers Association (NEMA) identifies two major sources of infrared emissions, namely: (1) spectral lines from the inert gas fill near electrodes, the anode and cathode; and (2) mercury lines from the main discharge or positive column. Accordingly, the first few minutes of ballast operation produce in the 800 nm – 850 nm bandwidth range, followed by a jump to about 1015 nm after five to ten minutes of operation (NEMA, 1999, pg. 6).

2.6   Iris Recognition Standards

The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) along with International Committee for Information Technology Standards (INCITS) of the American National Standard (ANSI) form a specialized system of standardization. Occasionally, these organizations offer contributions in the field of standardization with iris image capturing. Two standards that are accepted through ANSI, ISO, and IEC are the Iris Image Interchange Format and the Biometric Data Interchange Formats: Iris Image Data. The BM-ET300 iris camera currently uses ANSI for its standard.

2.6.1   Iris Image Interchange Format

The Iris Image Interchange Format was officially approved on May 13, 2004. The standard, according to INCITS, "contains a definition of attributes, a data record format, sample records and conformance criteria (INCITS, 2004, Introduction)." The format provides a couple of alternatives when using image interchange. These standards review the areas of: (1) Image Compression, (2) Image Pre-Processing, (3) Iris Image Data Record, (4) Iris Header Structures, and (5) Data Values in CBEFF Header (INCITS, 2004, pp. 1-15).

2.6.1.1   Rectilinear Image Storage Format

The Rectilinear Image Storage Format uses a raw, uncompressed array of values that are specified in the 'Joint Photographic Experts Group' (JPEG) image standard. This format suggests that images may be monochromatic or color with 256 or more intensity

levels (grey or per-color), and vary in size depending on field of view and compression (INCITS, 2004, pg. 1).

2.6.1.2 Polar Image Specification

The record size of the 'Polar Image Specification' may be as small as 2 Kbytes and be used in a raw or compressed format. This standard does require some extra pre-processing steps before compression, but it provides a most useful compact data structure with only iris information (INCITS, 2004, pg. 1).

2.6.2 Biometric Data Interchange Formats: Iris Image Data

The Iris Image Data standard is a specific standard that has been in a working group staring March 20, 2003. The standard outlines specific values and formats of both Rectilinear Image Storage Format and Polar Image Specifications (ISO & IEC, 2004, pp. 1-11). The specific areas of standardization include: (1) Image Compression, (2) Image Pre-Processing, (3) Iris Image Biometric Data Block, and (4) Iris Header Structures.

2.7 Review of Literature Conclusion

This chapter started by introducing the biometric security model and its importance to identity management. The biometric security model within iris scanning technology provided a physical and logical system that ensured identity management was handled properly and that the system and the confidentiality of human subjects were protected. Legal and security issues were presented to discuss potential needs for legislation to continue to protect the rights of the subjects and the rights of the managing organization of the security system. Finally, the discussion furthered the argument of infrared interference between subject and iris camera, subject and background light, and

background light and iris camera. A review of the published literature has revealed that a

potential for interference exists between near infrared emitting objects.

3 RESEARCH PROCEDURES

The methodology performed in conjunction with this research design involved obtaining approval, evaluating variables, controlling test populations, creating strong data, and maintaining biometric standards. The stated procedures continued to develop a security model of confidentiality, integrity, availability, and non-repudiation. Furthermore, the hardware and software configurations included those discussions used to establish a consistent model of statistically strong data using the established procedures. The statistical analysis of the population and sample size data was presented as a condition offered to establish a satisfactory research method.

3.1 Hardware Configuration

Processing of iris images returned simple Boolean algebra expressed outputs. This precludes the decision that specifications for the hardware were selected on the basis of equipment compatibility. The informative variables collected were iris images, iris data, and wavelength levels, five devices were used: (1) BM-ET300 iris camera, (2) Iris Server, (3) OOIBase32, (4) fluorescent lamp, and a (5) photometer. Each device function facilitated the process of iris image capture to meet what might be defined as a 'normal' environment. A normal environment was derived to be white & black ceilings and walls.

3.1.1 BM-ET300 Iris Camera

The BM-ET300 iris camera is proprietary and produced by the Panasonic Digital Communications & Security Company (Panasonic). Also, an optional administration software was supplied by Panasonic, specifically, (a) BM-ES300E, which handled subject accounts, and (b) BM-ET300 iris camera Setup Software, which were used to determine the configurations of the camera. The software modes included enrollment, identification, video monitoring, voice positioning guidance, and live indicator detection. Figure 3–1 illustrates the camera lens in the upper panel and the live indicator in the lower panel.

Figure 3–1 Panasonic BM-ET300 Iris Camera

3.1.1.1 Issues Installing

Since the BM-ET300 iris camera required proper positioning, configuration, and licensing, installation followed provided instructions. The parameters needed in preparing for installation necessitated additional equipment to support the installation requirements. The extra equipment included: (1) power cable, (2) LAN cable, and a (3) mountable rack.

The power cable was required to be UL style 1015 (AWG 14-18) or equivalent, with a maximum distance of 10 m. The LAN cable was required to be UL style 1666, CS-FT4 or equivalents using 10 Base-T/100 Base-TX (Category 5). The mountable rack was hand made to fit a sitting position for a research subject. Since standing or sitting was not relevant to the research, sitting was chosen for comfort. In normal usage at an airport, for example, a subject was seated. Furthermore, the size of the rack is determined by the testing environment and the administrators' preferences. In the case of this research it was designed to sit on a table so that a subject could sit comfortably for about twenty minutes.

3.1.2 Iris Server

The data collection utilized one computer tower. Prior to configuring the server software and application software, the hardware was selected to meet research delimitations. The hardware products are found in Table 3-1.

Table 3-1: Hardware Specifications

Hardware	Specification
CPU Architecture	X86 Based PC Celeron
Hard Drive	ST36811A – Generic (6GB)
Network Interface Card	3Com Etherlink XL 10/100 PU TXNIC (3C90SB-TX)
Computer Tower	Dell OptiPlex GX100
CPU Speed	700 MHz

The research design configuration hardware was compatible with Windows XP Professional and with adequate storage of at least 6 gigabytes. The hard disk drive also

needed to meet the standards of the operating system as well as the application, which was determined to be six gigabytes by Panasonic.

3.1.3   OOIBase32 Infrared Sensor

The Ocean Optics, Inc. OOIBase32 hardware reads the wavelengths emitting from a light source in its direct path. As seen in Figure 3-2, the sensor is placed in the direct path of the light source to read the wavelengths that are in direct contact with the camera. The device was designed to only be sensitive to wavelengths from 0-1000 nanometers (nm), which covered the spectrum relevant to this research.

Figure 3–2 OOIBase32 Infrared Sensor

3.1.4   Fluorescent Lamp

The research required the ability to change fluorescent illumination to include certain levels of testing during the iris image capture of each subject. A fluorescent lamp, which was dimmed by a rheostat switch, was selected to provide proper illumination without having to change equipment during the procedure. The power for the dimmable fluorescent lamp required an external power source (110V – 120V) to provide the appropriate background fluorescent light.

The lamp was produced by Sunpark Electronics Corporation and was supplied to Positive Energy for consumer distribution. The product is an alabaster shade, black with 55 watts 2C lamp. The lamp used protective glass that was tilted to provide a direct light source to the camera as seen in Figure 3-3 below. No further settings and adjustments were required to produce the necessary light. All glass windows were covered to ensure the only light source was the lamp.

Figure 3–3 Dimmable Fluorescent Lamp

3.1.5   Photometer

To capture the light intensity in foot-candles, a photometer was placed in the direct path of the fluorescent light source as seen in Figure 3-4. The reading provided the necessary determination of intensity levels of each iris capture.

The photometer was produced by Davis Instrumentation and is an A.W. Sperry version SLM-110. The photometer provided the necessary level measurements as the wavelengths moved into the near infrared range.

Figure 3–4 Davis Instrumentations Photometer

3.2 Software Configuration

Capturing iris images and associated data required software compatible with Windows XP Service Pack 2. The software was selected on the basic of platform compatibility found in these applications: (1) BM-ES300E, (2) OOIBase32 "USB 2000", and the (3) BM-ET300 SDK. Each application worked in harmony within Windows XP Professional to achieve the capture of required data for the research problem.

3.2.1 Windows XP Professional Configuration

Windows XP Service Pack 2 was installed using a full version from the university Microsoft site license provided by the Brigham Young University School of Technology. No further updates were obtained due to a lack of wire or wireless Internet connection. All configurations were based on default settings in Windows XP Service Pack 2.

Microsoft Office was installed to facilitate the capturing of images and iris data. All images are captured and copied to a Word document. No updates were installed and all configurations were based on default settings of Microsoft Office.

3.2.2   BM-ES300E Server Installation

The BM-ES300E utilizes a package that includes software application, server administration, and licensing. The proprietary nature of the software requires the licensing to be purchased and installed separately.

The BM-ET300 application interface utilized the basic installation CD and did not require additional services.   The server administration software required an install provided by Panasonic, which was sent through e-mail as part of its ongoing research support. The install allows configurations to be set for voice guidance, enrollment, or identification. Finally, the licensing CD was sent as further support from Panasonic as a 1,000-seat license. Since Panasonic was supporting the research, the license was sent with no charge. Running the install disk with all defaults immediately licensed the software.

3.2.3   OOIBase32 Implementation

The Brigham Young University Department of Physics provided the OOIBase32 light wave device that was used to analyze wavelengths up to 1000 nm. The chart in Figure 3–5 illustrated the intensity on the X-axis and the wavelength on the Y-axis. The intensity axis measured the number of times, called 'counts,' a wave came in contact with the OOIBase32. Likewise, the wavelength axis measured the frequency of light waves that came in contact with the OOIBase32. The near infrared readings began at about 700 nm and end around 900 nm wavelengths. The software was set to defaults and utilizes a USB connection to read real-time light measurements. The measurements were evaluated to determine statistically significant wavelengths for the research problem.

The data collected from these readings were used to determine readings from each device that were the same. The correlation of the readings was then used to determine phase errors that arose from wavelengths crossing paths also referenced as 'phase errors.'
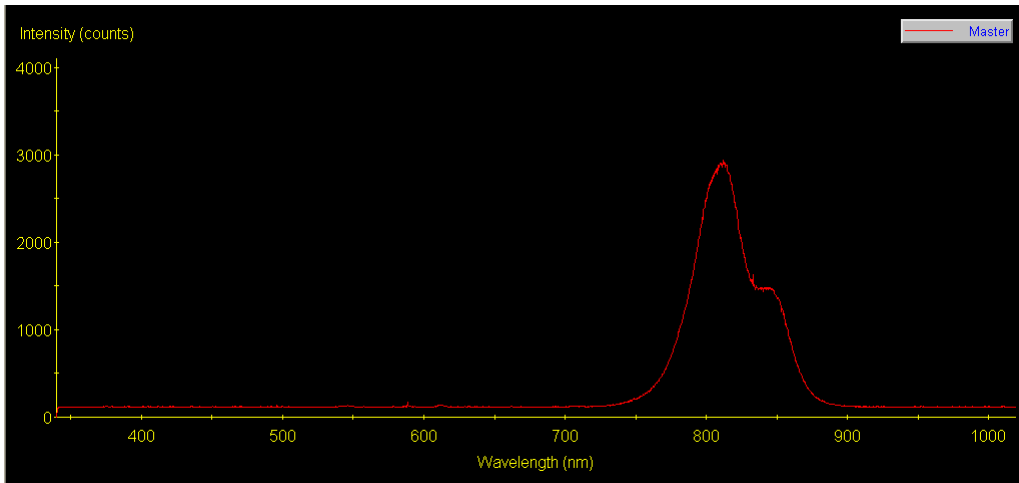
Figure 3–5 OOIBase32 Infrared Wave Reading

3.2.4   BM-ET300 SDK Code

The BM-ET300 Software Development Kit (SDK) was installed on Windows XP Professional. The code was written in Visual Basic 6.0, version 8176 and developed in Visual Studio 6.0. The function of the code was to streamline the process of capturing, processing, and analyzing the images. The raw code can be located in Appendix B.

3.2.4.1   Issues Installing

The SDK code written in Visual Basic 6.0 was not available in the newer versions of Visual Studio. Instead, Visual Studio 6.0 was installed to provide a functional development environment. Many hours of testing and trial were needed to ensure that data transfer and function processing were accurate.

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In order for the SDK to interact with the BM-ET300 Iris Server, extra libraries were placed in newly created folders on the root (commonly C:\) drive. Panasonic provided the folders and files on the SDK compact disc (CD) for copying to the drive.

3.3   Iris Capture Procedures

To further the understanding of the effects of illumination factors and subject interaction with the utilization of biometric iris technology, a basic statistical research method was employed. The research in this study consisted of a process beginning with the Internal Review Board Approval at Brigham Young University to use human subjects and followed with a logical control method to establish independent variables and constants. Next, a statistical method was used to evaluate the population selection, sample characteristics, data collection, and best practices. Finally, groupings were implemented to allow comparative analysis of the results.

Grouping 1 used a 0 nm (intensity = 0 counts) wavelength, Grouping 2 used a 700 nm wavelength, and Grouping 3 used an 800 nm wavelength. Grouping 1 was the designated benchmark with Grouping 2 and Grouping 3 being the comparative data groups. Since subject interaction resulted in a significant amount of failures during the first capture, the scans were removed as statistical outliers

The methodology covered the major areas of variance in biometric iris technology, namely: (1) confidentiality, (2) integrity, (3) availability, and (4) non-repudiation. The procedures intended to provide a method to reconstruct the test of variance with infrared light from an iris camera and infrared light from fluorescent ballasts.

3.3.1   Institutional Review Board (IRB) Approval

The first step in the process was to obtain Institutional Review Board (IRB) approval whereby iris images were obtained from subjects between the ages of 17 to the age of 60. The purpose accomplished two things: (1) benefited Panasonic with further understanding of illuminative affects on current iris technology, and (2) provided a technical demonstration of biometric iris technology to further the researcher's knowledge in regards to externalities affecting iris cameras.

The process of obtaining the 'use of subjects' approval required several steps. First, the Instiutional Review Board required a full introduction of the research problem and the assurance that the human subjects were not subjected to a harmful environment. Second, assurances were given that no preferential treatment or unintentional biases were introduced in the individual's participation in the sample. No incentives were available; therefore, all tests were with complete subject cooperation. Each institution followed its own procedures to remove liability from the researchers. Approval was obtained in writing and was valid for one year.

3.3.2   Sample Population

The sample population was determined by a power study, which calculated the probability that if a correlation existed, then the statistical significance test rejected the null hypothesis for the alternative hypothesis.

The power analysis seen in Figure 3-6 below suggests that an appropriate sample size is 704 scans ($p <= .1$). The majority of working subjects was between the ages of 18 and 30 and thus was able to use an iris biometric scanner in a public setting, such as an

airport or an entry to a business. All individuals were pulled from a technically oriented and non-technically oriented population.
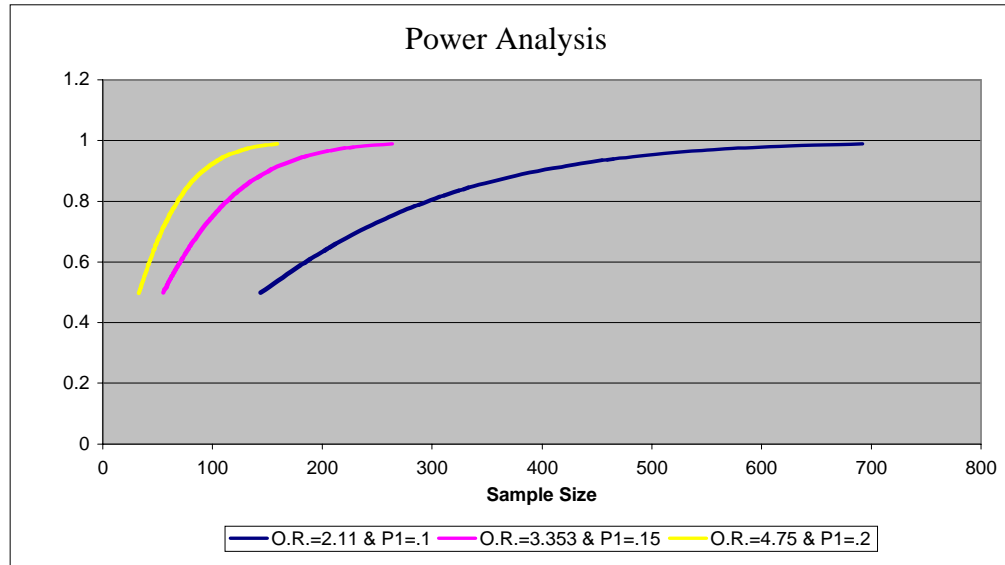
Figure 3–6 Sample Size Power Analysis

3.3.3 Population Selection

The population consisted of individuals from an educational environment. Brigham Young University was chosen due to its large size. Participants were chosen from among the student, faculty and staff of the various colleges across Brigham Young University, which consisted of 63 participants at 15-iris camera scans per person.

3.3.4 Sample Size

The total sample size was calculated using a power analysis with 95% confidence interval (Z=1.96), a statistically significant p value of 0.1, and a confidence interval 2.11. The power analysis was selected to provide a number of test subjects that gave a 95%

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confidence of statistical significance. The formula resulted in a minimum sample size (ss) of at least seven hundred four (704) test subjects. The total numbers of completed tests were 945 from a subject size of 63 people; which is 241 more samples than the required sample size, ensuring a statistically significant result, or a chance that the results were true. During the testing of each subject, fifteen scans were performed. Figure 3–7 illustrated the equation that determined the minimum sample size from the selected population, which consisted of thirty thousand (30,000) students.

$$ss = \frac{Z^2 * (p) * (1-p)}{c^2}$$

Figure 3–7 Sample Size Calculations

As seen above, Z=Z value (e.g. 1.96 for 95% confidence level), p = percentage picking a choice, expressed as decimal (0.5 used for sample size needed), and c=confidence interval, expressed as a decimal. The value returned represents the sample of the full population to be analyzed.

3.3.5   Sample Characteristics

The samples in this study corresponded to a bigger populace, since the physical nature of the eye was determined to be important to the research; although, a population extending to other nationalities with different physical eye structures were evaluated during Phase I (Daugman, 2001, pg.1). The sample came from a Brigham Young University demographics "of 6 percent daytime international students, 26 percent were from the Far East, 14 percent from South America, 14 percent from Canada, 13 percent

from Europe, 12 percent from Central America and Mexico, 7 percent from the Middle East and 7 percent from Eastern Europe and Russia (BYU, 2006)." Furthermore, the gender of the subjects was unrelated to the nature of the research problem. Larsson (et al) determined that gender was not relevant to the iris patterns and thus, the results were not compared to male or female subjects (Larsson, Pedersen, and Stattin, pg. 195, 2003).

3.3.6   Data Collection

Data collection required a process that gathered results efficiently and accurately. The process involved two phases to ensure these specifications were achieved. Phase I used 5 subjects at 20 scans each in order to find potential issues with the process. Phase II used 63 subjects to collect the raw data of the research.

3.3.6.1   Phase I

Phase I was designed to sort out issues as well as delineated potential skewing of data. First, the subject was placed in front of the camera and was explained the process by which the images were captured. Second, the camera administrator started the image capture, which took approximately 5 seconds. The software processed the image for the next 45 seconds and returned a Boolean result of the image. Third, the administrator captured the returned results and placed them into a spreadsheet. A copy of the image was saved and placed on a backup hard drive to ensure were accessible. Fourth, after each image is captured, the administrator changes the dimmable fluorescent lamp to a new illumination level to introduce the infrared wavelength to the camera. A photometer
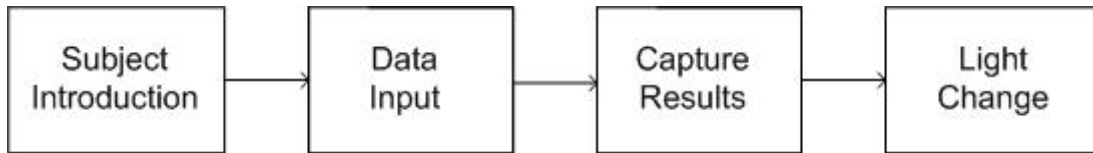
Figure 3–8 Phase I and II Procedure

read the intensity to determine it is the same illumination as other subjects at that specific level. Finally, the process of the image capture is performed another fourteen times.

The complete procedure takes approximately 15 minutes, allowing for only 4 subjects (60 scans) per hour. The research involves 2 females (both Caucasian), and 3 males (2 Caucasian and 1 Asian). Although previous research indicated race and gender did not affect the results, analysis of sample populations established that diversity was a part of a 'normal' environment.

3.3.6.2   Phase II

Phase II began with the collection of raw research data. As mentioned in Chapter 2, best practices were followed in preparing the process for data collection. Since the results returned successful and failed scans consistent to expectations, the study then proceeded with the procedures outlined in Phase I.

3.3.7   Biometric Best Practices

The process followed the best practices of biometric data collection utilized by the National Physical Laboratory (NPL) in England. The findings determined that four areas should be evaluated when testing biometric equipment. These areas were: (1) planning the evaluation, (2) data collection, (3) analysis, and (4) estimates. The baseline approach

of NPL provided a valuable tool to effectively and consistently derive repeatable results to further the study of biometrics data capture (NPL, 2005).

3.4   Methodology Summary

The research process provided the means to obtain test approval, control external factors, determined population selection, collected reliable data, and utilized best practices from literature review found in chapter two of this study. The methodology continued to outline the potential of security variance in biometric iris technology, namely confidentiality, integrity, availability, and non-repudiation. Furthermore, the procedures provided a method to reconstruct the test of variance with iris camera and with infrared light from fluorescent ballasts.

4 DATA ANALYSIS

The data collected within the procedures of the previous chapter were explained and analyzed. Furthermore, the data was organized into three groupings in order to extrapolate and illustrate variance between the different levels of near infrared wavelengths from fluorescent ballasts and in iris cameras. Grouping 1 data was referred to as the benchmark, since the wavelength and intensity were set to zero. The results from this grouping provided a standard for Grouping 2 and Grouping 3 to develop a statistical comparison. Grouping 2 consisted of data collected at a near infrared wavelength of 700 nm. This wavelength was relevant due to its common frequency in external light sources (Panasonic, 2003). Grouping 3 evaluated a higher wavelength of 820 nm. This wavelength was used as the final comparison due to the fact that the BM-ET300 iris camera used near infrared wavelengths in the 820 nm wavelength.

The analysis furthered the process of eliminating unnecessary variables in order to achieve relevant data. As discussed in the previous chapter, the number of the data sample were lowered to 882 due to the failure of the first scan, which still met the required sample size of 704 scans. The metric used to produce an outcome measure for each test subject was either a success or a failure, allowing for a comparative analysis of success to failure variance. The results of the total scans were output to a spreadsheet found in Appendix B.

4.1   Phase I Analysis

As mentioned in Chapter 3, Phase I was designed to determine potential issues, which exposed a couple of anomalies in the data. The first issue was the physical makeup of the subjects. An international student from Asia failed all 15 scans due to the physical narrowness of his eyes. Since the camera required 70% of the iris to be exposed, the image did not pass quality assurance and therefore, was rejected. Forcing the eyelids open only yielded 3 successful scans out of 15. Another issue was the lack of training with the device. Several of the subjects failed the first scan due to improper positioning of the eyes and head. Since the other subjects had wider eye structures, scans 2 – 15 instituted greater success. To prevent misuse, the device was designed to talk to the subject so they may position themselves properly. The misuse was attributed to the inexperience of the subject and was treated as an outlier.

4.2   Phase II Analysis

Phase II gathered scans in order to determine points of failure with the image created by the iris camera. As discussed in chapter 2, external near infrared waves cross-phased with the internal near infrared waves of the iris camera. Pixel distortions from phase errors lead to changing iris codes from the same subject. This research found that the external near infrared waves were significant between Grouping 1 and Grouping 3 and insignificant between Grouping 1 and Grouping 2. A comparative review suggested variance in statistical significance (p <= .01) between groupings. Additionally, the results failed to reject the null hypothesis that the iris code will not change as near infrared wavelength increases. Of the 945 tests performed (63 people at 15 scans each), 834 out of 945 scans were successful at 88.25% and 111 out of 945 scans were failures at 11.75%.

After the removal of the outliers, 882 tests (63 people at 14 scans each) 791 scans were successful out of 945 scans at 89.68% and 91 scans out 945 scans were failures at 10.32%. A 1.43% difference occurred when the outliers were removed from the sample group.

The research indicated that as the near infrared wavelength increases, the iris camera failed. The results further countered that as infrared waves increased, the performance of the camera increased. For example, a comparison between Grouping 1 and Grouping 2 showed a slight improvement in success rates. Grouping 1 had an 82.65% success rate while Grouping 2 had an 87.41% success. Furthermore, Grouping 3 had a success of 100%, which were an improvement of 12.59% from Grouping 2 and a 17.35% improvement from Grouping 1.

The results indicated that Grouping 1 and Grouping 2 generated similar success rate and differed by 4.76% success. The variation between the two created a large enough difference in success. A comparison between Grouping 1 and Grouping 3 revealed that as the near infrared reached the 820 nm wavelength, the success of the device was a 100%. The variation between Grouping 1 and Grouping 3 were statistically significant since the success differed by 12.59%. The data suggested that near infrared light from fluorescent tubes factored into the success of a scan when the wavelengths are between 0 nm (intensity = 0 counts) and 820 nm wavelengths.

4.2.1 Grouping 1 at $\Lambda = 0$ nm (intensity = 0), Benchmark

Grouping 1 is benchmarked using zero near infrared wave intensity to examine the changes as the near infrared intensity increases using the standard of methods and procedures discussed in Chapter 3. Grouping 1 substantiates that 7 people are scanned 14

times each resulting in a specific success rate. The resulting benchmarks for success and

failure for the iris scans are shown in Table 4-1.

Table 4-1: Grouping 1 at Λ = 0 nm (intensity = 0), Benchmark

ID	Λ = 0nm (intensity = 0 counts)	#Scans	Success
1	0	14	14
2	0	14	11
3	0	14	9
4	0	14	14
5	0	14	13
6	0	14	14
7	0	14	6

The first scan of each subject had a 31.75% chance of failing as compared to the

other fifteen scans having the probability of failing at 6.35% and 12.70%. Such a high

failure rate introduced a variable of incorrect subject interaction. As a statistical outlier,

the first scan of each subject is removed from the 105 scans creating only a frequency of

fourteen to evaluate the scans that were only affected by the variable of near infrared

wavelengths. Each subject then is evaluated with 14 scans totaling 98 scans in the

grouping. As Table 4-1 shows, the success at the wavelength of 0 nm (intensity = 0

counts) of Grouping 1 had as small as 6 successful scans and as high as 14 successful

scans. The total of 81 successful scans produced an 82.65% success rate.

4.2.2   Grouping 2 at 700 nm Wavelength

Table 4-2 shows the success rate while holding the wavelength at the 700 nm

range. The external fluorescent heat is introduced to the camera causing a sudden

increase to the visible spectrum of light. Variations in successful scans are expected with

Table 4-2: Grouping 3 at 820 nm Wavelength

ID	Λ = Wavelength	#Scans _	Success
8	700	14	10
9	700	14	10
10	700	14	12
11	700	14	14
12	700	14	14
13	700	14	12
14	700	14	14
15	700	14	13
16	700	14	14
17	700	14	14
18	700	14	1
19	700	14	14
20	700	14	14
21	700	14	13
22	700	14	14
23	700	14	12
24	700	14	14
25	700	14	14
26	700	14	7
27	700	14	14
28	700	14	13
29	700	14	14
30	700	14	14
31	700	14	14
32	700	14	14
33	700	14	13
34	700	14	12
35	700	14	14
36	700	14	13
37	700	14	14
38	700	14	13
39	700	14	14
40	700	14	7
41	700	14	13
42	700	14	5
43	700	14	13
44	700	14	5
45	700	14	13
46	700	14	14
47	700	14	14
48	700	14	14
49	700	14	10

such an increase, yet the observed results show that the success rate was at 87.45%.

Empirically, fluorescent illumination seems to not affect the iris camera. The data was

important in that it validated the empirical data and established quantitative strength of success.

4.2.3 Grouping 3 at 820 nm Wavelength

Grouping 3 provided strong support that at the 820 nm wavelength from the external fluorescent lamp provided 100% success. The probability of success was high when the wavelength was at 820 nm with the BM-ET300 iris camera.

Table 4-3: Grouping 3 at 820 nm Wavelength

ID	Λ = Wavelength	#Scans	Success
51	800	14	14
52	800	14	14
53	800	14	14
54	800	14	14
55	800	14	14
56	800	14	14
57	800	14	14
58	800	14	14
59	800	14	14
60	800	14	14
61	800	14	14
62	800	14	14
63	800	14	14

4.2.4 Grouping 1 and Grouping 2 Comparison

The success rate of 87.41% with 635 scans in Grouping 2 showed a strong correlation with Grouping 1 and its 82.65% success rate. Grouping 1 and Grouping 2 in a t-test have an 18.50% chance of being truly different. Since the success of 82.65% and the success of 87.41% between Grouping 1 and Grouping 2 was 4.76%, the two groupings were insignificance.

With Grouping 1 being the benchmark, Grouping 2 showed the success improvement as the near infrared wavelength increased. The resulting analysis of success for the iris scans was shown below in Figure 4-1.
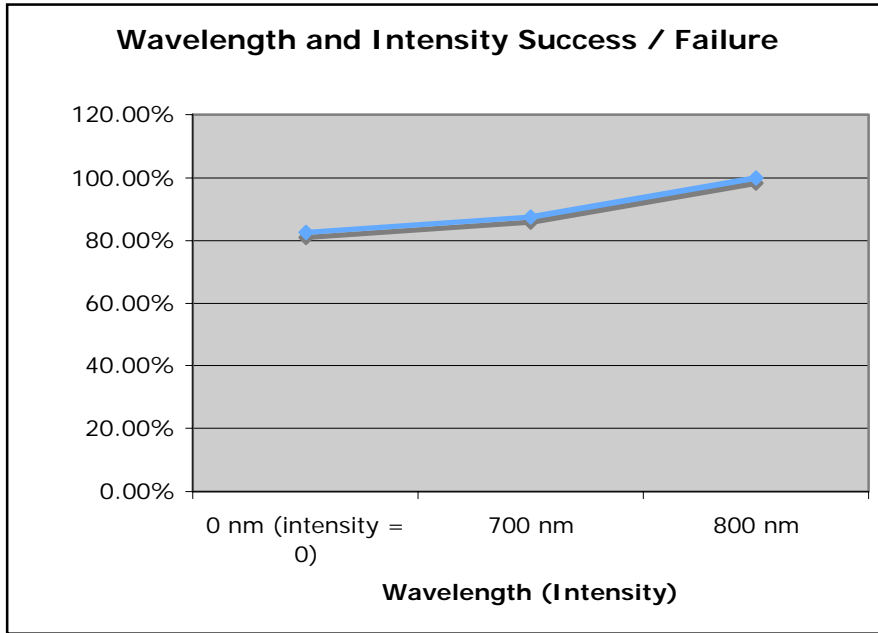
Figure 4–1 Data Analysis Summary

The success rate of 82.65% at the wavelength of 0 nm (intensity = 0 counts) suggested that scan failures were not due to phase errors. Moving from 0 nm (intensity = 0 counts) to 700 nm showed an improvement of just fewer than five percent at 87.41%. Failures actually decreased as the wavelength increased. When evaluating the successes between the two groups, statistically the variation was insignificant and the results were relatively similar. Ultimately, the two groupings were categorized together with similar results.

4.2.5   Grouping 1 and Grouping 3 Comparison

The success rate of 100% with 588 scans in Grouping 3 showed a significant correlation with Grouping 1 and its 82.65% success rate. Since the success and failure variation between Grouping 1 and Grouping 3 was more than twice the amount of Grouping 1 and Grouping 2, statistically the groupings were significantly different with a t-test producing an 86.92% chance of the groupings being truly different. The difference between the two grouping comparisons were statistically significant and suggests that as wavelengths increase to a 'normal' illuminative setting the scan success will increase

Grouping 3 was used to compare variation between the success rates of grouping 1. With Grouping 1 being the benchmark, Grouping 2 showed the success improvement as the near infrared wavelength increased.

The success rate of 100% at the wavelength of 820 nm suggested that scan successes were not due to phase errors. Moving from 0 nm (intensity = 0 counts) to 820 nm showed an improvement of 4.76% at 87.41% success rate. Failures continued to decrease as the wavelength increases. When evaluating the successes between the two groupings, statistically the variation was significant, or not due to chance, and suggested better illumination quality when the wavelengths were the same. The data provided incremental value since waves from the fluorescent lamp produced waves at the 700 nm range when the light was turned to the on position.

5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

The fundamental hypothesis was that as the wavelengths of fluorescent illumination reach and enter near infrared, the cross phasing of incremental (0 nm, intensity = 0 counts and 820 nm) wavelengths distorted the image and then corrupted the iris data of the BM-ET300 iris camera. The intensity counts were the number of times a wave came in contact with the OOIBase32, as referenced in section 3.2.3 of Chapter 2. The hypothesis was tested in two phases, Phase I and Phase II, with procedures involving three specified groupings, referenced as Grouping 1, Grouping 2, and Grouping 3.

Phase I tested the procedure and found several issues that have been statistically accounted for as outliers. Phase II continued the testing of the raw data set to prepare for the variation analysis among groupings.

Grouping 1 used a 0 nm (intensity = 0 counts) wavelength, Grouping 2 used a 700 nm wavelength, and Grouping 3 used an 820 nm wavelength. Grouping 1 was the designated benchmark with Grouping 2 and Grouping 3 being the comparative data groups. Since subject interaction resulted in a significant amount of failures during the first capture, the scans were removed as statistical outliers.

Furthermore, for Grouping 1 of the research, samples of 98 scans were selected to evaluate the infrared intensity of the camera with no external background near infrared

light. Grouping 1 was used to establish the benchmark of the research. The respondents were then placed in front of the iris camera to evaluate the success at no wavelength of 0 nm (intensity = 0 counts). The results of Grouping 1 indicate that near infrared emitted from the camera was not affected by complete blackness (Λ = 0 nm, intensity = 0 counts). Without any external phasing of waves, the near infrared from the camera was sufficient enough to capture the iris features and correctly used the algorithm to capture the individual iris characteristics.

For Grouping 2 of the research, samples of 588 scans were used to scan for phase errors of infrared light from the iris camera with near infrared light from external fluorescent illumination. The test of success and failures were used to compare variation between the success results of Grouping 1 and the success results of Grouping 2. The results continued to suggest a minimal improvement of success from Grouping 1 to Grouping 2. The results of the research indicated that the specific fluorescent infrared wavelengths used in Grouping 1 and Grouping 2 did not statistically affect the success of the iris camera. The success of the device improved from about 82% to about 89%, a 7% improvement during the capturing process.

For Grouping 3 of the research, samples of 182 scans were used to determine phase errors of infrared light from the iris camera with near infrared light from external fluorescent illumination. The success and failures were used to compare variation between the success results of Grouping 1 and the success results of Grouping 3. Grouping 3 returned surprising results of 100%. Each scan was successfully captured during the process. The results suggested an increased improvement of success from Grouping 1 to Grouping 3. Furthermore, the results of the research indicated that the

specific fluorescent near infrared wavelengths used in Grouping 1 and Grouping 3 did statistically affect the success of the iris camera. The success of the device improved from about 82% to about 100%, an 18% improvement during the capturing process. This success may be attributed to the ability of the subject to see the device and position them correctly beginning with the first scan. As seen in Figure 5-1, a Chi-Square analysis indicated that a 91.33% probability existed that the collected data (referenced in Chapter 4) fell within a 95% confidence interval.

```
              Statistics of Order by Success/Failure

      Statistic                      Frequency          Probability
      --------------------------------------------------------------
        Chi-Square                      13                0.9133
        Likelihood Ratio Chi-Square    13                0.9128
        Mantel-Haenszel Chi-Square      1                0.1658

                         Sample Size = 882
```
Figure 5–1 Chi-square Analysis

With a 95% confidence interval, the collected data indicated that the stated hypothesis was false; the researcher failed to reject the null hypothesis. Increases in failures were expected, but the data showed otherwise. These outcomes continued to illustrate external variables such as illumination have an affect on the iris capturing device. The fact that the capture process improved while increasing fluorescent infrared wavelength suggested that illumination did affect the device. Higher levels of infrared intensity seemed to improve the results. The illumination levels used settings ranging from no infrared light to 820 nm wavelength.

5.2   Assumptions and Delimitations Summary

The data collection process developed the proposal that phase interference of wavelengths changes the bit structure due to image quality. The specific assumption observed through the research seemed false. After the statistical quantification of the data, the analysis furthers the empirical data that an increase in fluorescent infrared seems to not have a significant effect on the outcome of the image capture process. Of the first scans, 31.75% of the participants of the research encountered subject mistake during the first scan of the session. Only 11.11% of the subject's encountered mistakes with scan 2 – scan 15. With a 20% increase of mistakes from the first scan to the following scans, the data was found to be an outlier in the final findings.

The delimitation in chapter one may have some effect on the data collected during the image capture process. The first delimitation specifies that the study was limited to participants from Brigham Young University (BYU). The size of the university population is currently 30,000. Since gender does not play a role in the data, the population is sufficient enough to support a sample size of 704 with 882 subjects from the population.

The second delimitation states that the diversity of nationality, gender, and race are not necessary in conducting thorough data collection of iris samples. The university population is currently 91% Caucasian, while the other 9% are considered multicultural. Brigham Young University currently has 4% Asian or Pacific Islander, while Native American and African American's make up 5% of BYU's student population (byu.edu, 2006). For the purpose of this study gender was not analyzed.

The third delimitation states that the illumination reflection and refraction do not affect the results of the iris camera since the camera works at the infrared wavelength. Thus, the effects that reflection and refraction may have are natural and are assumed part of the data.

The final delimitation stated that variables such as eyelash interference and eye dilation are accounted for in the algorithm of the BM-ET300 software. Since the algorithm accounts for the interference of eyelashes, the success and failures of such features are a part of the collected data and the very nature of the research.

Furthermore, the subjects must be trained to use the Panasonic BM-ET300 so that false rejections may be minimized and accurate readings of the device are the result. Whether or not infrared of a higher intensity may affect the readings is currently unknown. The research is focusing on maximum illumination within a normal illuminated setting.

5.3   Recommendations for Further Research

The present research has identified areas for continued research that could expand the usability of iris biometric technology. Further analysis should be undertaken with regard to subject interaction during scans and enrollment. Finding methods to reduce the failures during enrollment would be a valuable tool during iris technology design. Furthermore, pushing the illumination spectrum of higher wavelengths of infrared illumination would challenge the device and further the elemental issue underlying the current research. Since shorter wavelengths are beyond the scope of this research and may push the boundary of safety to eye tissue, it is deemed that continuing research may not progress as rapidly as other issues.

Further research could be conducted in all industries focused upon this research, such as training and technology. High security locations such as government, financial institutions, and international airports could benefit from the development of iris scanning technology. With security becoming multi-modal (iris, retina, hand, face, and etc.), or multidimensional, a camera that handles these many types of biometric security could be evaluated. Also, studying the potential to use visible light instead of infrared for the device is an area that is currently being researched. This research implemented an overview not specifically targeted individuals of specific age, gender, career, or education.

Another area of research would be to analyze and compare cross illumination (i.e. fluorescent, halogen, and incandescent illumination in the same room). Rooms are being designed to use different types of light and therefore may be a viable issue when implementing a security device that may be affected by the light. Other areas may include researching devices that can account for external variables so that it may be used outdoors. Continued research could be done in the area of developing filters to allow only a certain amount of infrared to come in contact with the device while scanning outside.

Other issues made manifest during the process were the physical makeup of the subjects. The study evaluated one Asian student and suggests nationality may or may not affect the success of the device. Continuing research in the area of eye structures and ways to accommodate for all eye structures should be reviewed.

Many areas of research have been presented and currently provide valuable information for further research. The research indicates that the BM-ET300 iris camera provides increasing success rates as the wavelength increases. Fluorescent infrared

appears to not be a factor when capturing an image in normal room conditions. The future of infrared biometric technology remains unclear as security paradigms and needs change. Although, biometric iris scanning comes from a visual identification to a digital identification, the life cycle remains unclear as to when iris technology matures or dies. However, it is evident that biometric iris technology must first continue to overcome image-capturing barriers before it becomes a mainstream product in any setting and in any environment.

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APPENDICES

APPENDIX A. SDK SOURCE CODE

```
Option Explicit

Dim mFileSysObj As New FileSystemObject
Dim mFile As File
Dim mTxtStream As TextStream
Dim filecounter As Integer

Private m_oCn As Object
Private m_oIris As Object

Private Const M_SUCCESS As Long = 0
Private Const M_ERROR As Long = -1
Private Const M_WARNING As Long = -2

Private WithEvents LogEvent As ES300SDK.LogEvent

Private Sub chkAllGet_Click()

End Sub

Private Sub cmdAccLogClear_Click()

    txtAccLogEvents.Text = ""

End Sub

Private Sub cmdAlmLogClear_Click()

    txtAlmLogEvents.Text = ""

End Sub


Private Sub cmdCamera_Add_Click()

    Dim oCamera As Object
```

```vb
Dim rtn As Long
Dim sTemp As String
Dim oError As Object

On Error GoTo VB_Err

Me.MousePointer = vbHourglass

Set oCamera = CreateObject("ES300SDK.Camera")

oCamera.CameraID = txtCameraID.Text
oCamera.CameraName = txtCameraName.Text
oCamera.IPAddress = txtIPAddress.Text
oCamera.RecognitionMode = txtRecogMode.Text
oCamera.ServerCertification = txtServerMode.Text
oCamera.AudioMode = txtAudioMode.Text
oCamera.GuidanceLanguage = txtGuidance.Text
oCamera.Output1 = txtOutput1.Text
oCamera.Output2 = txtOutput2.Text
oCamera.LiveIndicator = txtLive.Text
oCamera.SiteCode = txtSiteCode.Text
oCamera.UserCode = txtUserCode.Text
oCamera.PulseWidth = txtPulseWidth.Text
oCamera.PulseInterval = txtPulseInterval.Text

rtn = m_oCn.Camera_Add(oCamera)

If rtn = 0 Then
   txtResult.Text = "Camera_Add method is successfully completed."
Else
   sTemp = "Camera_Add method is unsuccessfully completed."
   For Each oError In m_oCn.Errors
      sTemp = sTemp & vbCrLf & "[Database.Errors]"
      'Get error information from Error object
      sTemp = sTemp & vbCrLf & "Number : " & oError.Number
      sTemp = sTemp & vbCrLf & "Source : " & oError.Source
      sTemp = sTemp & vbCrLf & "Description : " & oError.Description
      sTemp = sTemp & vbCrLf
   Next

   txtResult.Text = sTemp

End If

Me.MousePointer = vbDefault
Exit Sub
```

```
VB_Err:
    Me.MousePointer = vbDefault
    MsgBox Err.Description, , Err.Source
End Sub


Private Sub cmdCamera_Get_Click()

    Dim oCamera As Object
    Dim rtn As Long
    Dim sTemp As String
    Dim oError As Object
    Dim oGroup As Object

    On Error GoTo VB_Err

    Me.MousePointer = vbHourglass

    rtn = m_oCn.Camera_Get(txtCameraID.Text, oCamera)

    If rtn = 0 Then
        txtResult.Text = "Camera_Get method is successfully completed."

        txtCameraName.Text = oCamera.CameraName
        txtIPAddress.Text = oCamera.IPAddress
        txtRecogMode.Text = oCamera.RecognitionMode
        txtServerMode.Text = oCamera.ServerCertification
        txtAudioMode.Text = oCamera.AudioMode
        txtGuidance.Text = oCamera.GuidanceLanguage
        txtOutput1.Text = oCamera.Output1
        txtOutput2.Text = oCamera.Output2
        txtLive.Text = oCamera.LiveIndicator
        txtSiteCode.Text = oCamera.SiteCode
        txtUserCode.Text = oCamera.UserCode
        txtPulseWidth.Text = oCamera.PulseWidth
        txtPulseInterval.Text = oCamera.PulseInterval
        txtMode.Text = oCamera.ActionMode
        txtState.Text = oCamera.State

        lstAllGroups.Clear

        'Get group information from Group object
        For Each oGroup In oCamera.Groups
            lstAllGroups.AddItem oGroup.GroupName
        Next
```

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```
    Else
      sTemp = "Camera_Get method is unsuccessfully completed."
      For Each oError In m_oCn.Errors
         sTemp = sTemp & vbCrLf & "[Database.Errors]"
         'Get error information from Error object
         sTemp = sTemp & vbCrLf & "Number : " & oError.Number
         sTemp = sTemp & vbCrLf & "Source : " & oError.Source
         sTemp = sTemp & vbCrLf & "Description : " & oError.Description
         sTemp = sTemp & vbCrLf
      Next
      txtResult.Text = sTemp
    End If

    Me.MousePointer = vbDefault
    Exit Sub

VB_Err:
    Me.MousePointer = vbDefault
    MsgBox Err.Description, , Err.Source
End Sub


Private Sub cmdCamera_Reset_Click()

    Dim rtn As Long
    Dim oError As Object
    Dim sTemp As String
    Dim sCameraID As String

    On Error GoTo VB_Err

    txtResult.Text = ""

    Me.MousePointer = vbHourglass

    sCameraID = txtCameraID.Text

    'Camera_Reset
    rtn = m_oCn.Camera_Reset(sCameraID)

    If rtn = 0 Then
      txtResult.Text = "Camera_Reset method is successfully completed."
    Else
      sTemp = "Camera_Reset method is unsuccessfully completed."
      For Each oError In m_oCn.Errors
         sTemp = sTemp & vbCrLf & "[Database.Errors]"
```

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```vb
        'Get error information from Error object
        sTemp = sTemp & vbCrLf & "Number : " & oError.Number
        sTemp = sTemp & vbCrLf & "Source : " & oError.Source
        sTemp = sTemp & vbCrLf & "Description : " & oError.Description
        sTemp = sTemp & vbCrLf
    Next

    txtResult.Text = sTemp

  End If

  Me.MousePointer = vbDefault
  Exit Sub

VB_Err:
  Me.MousePointer = vbDefault
  MsgBox Err.Description, , Err.Source

End Sub

Private Sub cmdCaptureRecog_Click()

  Dim oError As Object
  Dim lFileNumber As Long
  Dim bData() As Byte
  Dim rtn As Long
  Dim OnImage As Long
  Dim sTemp As String

  On Error GoTo VB_Err

  Me.MousePointer = vbHourglass

  txtResult.Text = ""

  If chkPicture.Value = 1 Then
     OnImage = 1
  Else
     OnImage = 0
  End If

  'Iris image capturing for recognition
  'This method is asynchronous.
  'Refer StillCapture in database object for image condition.
  rtn = m_oCn.CaptureRecog(OnImage)
```

```
      If rtn = 0 Then
        'Successfully completed.
        txtResult.Text = "CaptureRecog method is successfully completed."
        lblCapture.Caption = "Iris image capturing"
        tmrCaptureStatus.Enabled = True
      Else
        'Unsuccessfully completed.
        sTemp = "CaptureRecog method is unsuccessfully completed."
        For Each oError In m_oCn.Errors
          sTemp = sTemp & vbCrLf & "[Database.Errors]"
          'Get error information from Error object
          sTemp = sTemp & vbCrLf & "Number : " & oError.Number
          sTemp = sTemp & vbCrLf & "Source : " & oError.Source
          sTemp = sTemp & vbCrLf & "Description : " & oError.Description
          sTemp = sTemp & vbCrLf
        Next
        txtResult.Text = sTemp
      End If

      Me.MousePointer = vbDefault
      Exit Sub
VB_Err:
      Me.MousePointer = vbDefault
      MsgBox Err.Description, , Err.Source

End Sub

Private Sub cmdDistribute_Camera_Click()

      Dim rtn As Long
      Dim oError As Object
      Dim sTemp As String
      Dim sCameraID As String

      On Error GoTo VB_Err

      txtResult.Text = ""

      Me.MousePointer = vbHourglass

      sCameraID = txtCameraID.Text

      'Distribute_Camera
      rtn = m_oCn.Distribute_Camera(sCameraID)

      If rtn = 0 Then
```

```vb
      txtResult.Text = "Distribute_Camera method is successfully completed."
      tmrDistributeStatus.Enabled = True
   ElseIf rtn = -2 Then
      sTemp = "Distribute_Camera method is warning completed."
      For Each oError In m_oCn.Errors
         sTemp = sTemp & vbCrLf & "[Database.Errors]"
         'Get error information from Error object
         sTemp = sTemp & vbCrLf & "Number : " & oError.Number
         sTemp = sTemp & vbCrLf & "Source : " & oError.Source
         sTemp = sTemp & vbCrLf & "Description : " & oError.Description
         sTemp = sTemp & vbCrLf
      Next
      txtResult.Text = sTemp
      tmrDistributeStatus.Enabled = True
   Else
      sTemp = "Distribute_Camera method is unsuccessfully completed."
      For Each oError In m_oCn.Errors
         sTemp = sTemp & vbCrLf & "[Database.Errors]"
         'Get error information from Error object
         sTemp = sTemp & vbCrLf & "Number : " & oError.Number
         sTemp = sTemp & vbCrLf & "Source : " & oError.Source
         sTemp = sTemp & vbCrLf & "Description : " & oError.Description
         sTemp = sTemp & vbCrLf
      Next

      txtResult.Text = sTemp

   End If

   Me.MousePointer = vbDefault
   Exit Sub

VB_Err:
   Me.MousePointer = vbDefault
   MsgBox Err.Description, , Err.Source

End Sub

Private Sub cmdDistribute_Flag_Click()

   Dim rtn As Long
   Dim oError As Object
   Dim sTemp As String
   Dim nState As Long

   Me.MousePointer = vbHourglass
```

```
   txtResult.Text = ""
   lblDistribute.Caption = ""

   'It is necessary to distribute the Iris Data.
   nState = m_oCn.Distribute_Flag
   If nState = 1 Then
      lblDistribute.Caption = "data distributed."
   ElseIf nState = 0 Then
      lblDistribute.Caption = "No data distributed."
   Else
      lblDistribute.Caption = "processing"
   End If

   Me.MousePointer = vbDefault

End Sub

Private Sub cmdGroup_Add_Click()

   Dim oGroup As Object
   Dim oCamera As Object
   Dim i As Integer
   Dim oUser As Object
   Dim oError As Object
   Dim rtn As Long
   Dim sTemp As String
   Dim sCameraID As String
   Dim pos As Integer

   On Error GoTo VB_Err

   Me.MousePointer = vbHourglass

   txtResult.Text = ""

   'Create Group object
   Set oGroup = CreateObject("ES300SDK.Group")

   'Set group information in Group object
   'New group registration
   oGroup.GroupName = txtGroupName.Text
   sTemp = txtCameraID_G.Text
   Do While True
      pos = InStr(1, sTemp, ",", vbTextCompare)
      If pos = 0 Then
         Exit Do
```

```vb
      Else
         sCameraID = Mid(sTemp, 1, pos - 1)
         Set oCamera = CreateObject("ES300SDK.Camera")
         oCamera.CameraID = sCameraID
         oGroup.Cameras.Add oCamera
         sTemp = Mid(sTemp, pos + 1, Len(sTemp) - pos)
      End If
   Loop

   rtn = m_oCn.Group_Add(oGroup)
   If rtn = 0 Then
   'Successfully completed.
      txtResult.Text = "Group_Add method is successfully completed."

   Else
   'Unsuccessfully completed.
      sTemp = "Group_Add method is unsuccessfully completed."
      For Each oError In m_oCn.Errors
         sTemp = sTemp & vbCrLf & "[Database.Errors]"
         'Get error information from Error object
         sTemp = sTemp & vbCrLf & "Number : " & oError.Number
         sTemp = sTemp & vbCrLf & "Source : " & oError.Source
         sTemp = sTemp & vbCrLf & "Description : " & oError.Description
         sTemp = sTemp & vbCrLf
      Next

      txtResult.Text = sTemp

   End If

   Set oGroup = Nothing
   Set oCamera = Nothing

   Me.MousePointer = vbDefault
   Exit Sub
VB_Err:
   Me.MousePointer = vbDefault
   MsgBox Err.Description, , Err.Source
End Sub

Private Sub cmdIrisRecog_Click()

   Dim rtn As Long
   Dim oError As Object
   Dim sTemp As String
   Dim sUserID As String
```

```vb
    On Error GoTo VB_Err

    Me.MousePointer = vbHourglass

    txtResult.Text = ""

    'Iris Recognition
    rtn = m_oCn.Iris_Recog(m_oIris, sUserID)

    'Successfully completed.
    If rtn = 0 Then
    'Recognition accepted
        sTemp = "Iris_Recog method is successfully completed." & vbCrLf
        sTemp = sTemp & "  RecogOK UserID   F" & sUserID
        txtResult.Text = sTemp
    ElseIf rtn = 1 Then
    'Recognition rejected
        sTemp = "Iris_Recog method is successfully completed." & vbCrLf
        sTemp = sTemp & "  RecogNG"
        txtResult.Text = sTemp

    Else
        'Unsuccessfully completed.
        sTemp = "Iris_Recog method is unsuccessfully completed."
        For Each oError In m_oCn.Errors
            sTemp = sTemp & vbCrLf & "[Database.Errors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
        Next

        txtResult.Text = sTemp

    End If

    Me.MousePointer = vbDefault
    Exit Sub
VB_Err:
    Me.MousePointer = vbDefault
    MsgBox Err.Description, , Err.Source

End Sub

Private Sub cmdIrisSetLeft_Click()
```

```vb
    Dim rtn As Long
    Dim oError As Object
    Dim sTemp As String

    On Error GoTo VB_Err

    Me.MousePointer = vbHourglass

    txtResult.Text = ""

    If m_oIris Is Nothing Then
       'Set iris data
       Set m_oIris = CreateObject("ES300SDK.Iris")
    End If

    m_oIris.UserID = txtUser(0).Text

    'Set left iris data
    rtn = m_oCn.Iris_SetLeft(m_oIris)

    If rtn = 0 Then
       'Successfully completed.
       txtResult.Text = "Iris_SetLeft method is successfully completed."
    Else
       'Unsuccessfully completed.
       sTemp = "Iris_SetLeft method is unsuccessfully completed."
       For Each oError In m_oCn.Errors
          sTemp = sTemp & vbCrLf & "[Database.Errors]"
          'Get error information from Error object
          sTemp = sTemp & vbCrLf & "Number : " & oError.Number
          sTemp = sTemp & vbCrLf & "Source : " & oError.Source
          sTemp = sTemp & vbCrLf & "Description : " & oError.Description
          sTemp = sTemp & vbCrLf
       Next

       txtResult.Text = sTemp

    End If

    Me.MousePointer = vbDefault

    Exit Sub
VB_Err:
    Me.MousePointer = vbDefault
    MsgBox Err.Description, , Err.Source
```

```
End Sub

Private Sub cmdIrisSetRight_Click()

    Dim rtn As Long
    Dim oError As Object
    Dim sTemp As String

    On Error GoTo VB_Err

    Me.MousePointer = vbHourglass

    txtResult.Text = ""

    If m_oIris Is Nothing Then
        'Set iris data
        Set m_oIris = CreateObject("ES300SDK.Iris")
    End If

    m_oIris.UserID = txtUser(0).Text

    'Set right iris data
    rtn = m_oCn.Iris_SetRight(m_oIris)

    If rtn = 0 Then
        'Successfully completed.
        txtResult.Text = "Iris_SetRight method is successfully completed."
    Else
        'Unsuccessfully completed.
        sTemp = "Iris_SetRight method is unsuccessfully completed."
        For Each oError In m_oCn.Errors
            sTemp = sTemp & vbCrLf & "[Database.Errors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
        Next

        txtResult.Text = sTemp

    End If
    Me.MousePointer = vbDefault

    Exit Sub
VB_Err:
```

```
      Me.MousePointer = vbDefault
      MsgBox Err.Description, , Err.Source


End Sub


Private Sub cmdIrisVerify_Click()


   Dim rtn As Long
   Dim oError As Object
   Dim sTemp As String
   Dim sUserID As String
   Dim oIris As Object


   On Error GoTo VB_Err


   Me.MousePointer = vbHourglass


   'Get iris data
   rtn = m_oCn.Iris_Get(txtUser(0).Text, oIris)
   If rtn <> 0 Then
      'Unsuccessfully completed.
      sTemp = "Iris_Get method is unsuccessfully completed."
      For Each oError In m_oCn.Errors
         sTemp = sTemp & vbCrLf & "[Database.Errors]"
         'Get error information from Error object
         sTemp = sTemp & vbCrLf & "Number : " & oError.Number
         sTemp = sTemp & vbCrLf & "Source : " & oError.Source
         sTemp = sTemp & vbCrLf & "Description : " & oError.Description
         sTemp = sTemp & vbCrLf
      Next


      txtResult.Text = sTemp
      Me.MousePointer = vbDefault
      Exit Sub
   End If


   txtResult.Text = ""


   'Iris Recognition
   rtn = m_oCn.Iris_Verify(m_oIris, oIris)


   'Successfully completed.
   If rtn = 0 Then
   'Recognition accepted
      sTemp = "Iris_Verify is successfully completed." & vbCrLf
      sTemp = sTemp & "  VerifyOK"
```

```vb
      txtResult.Text = sTemp
   ElseIf rtn = 1 Then
   'Recognition rejected
      sTemp = "Iris_Verify is successfully completed." & vbCrLf
      sTemp = sTemp & "  VerifyNG"
      txtResult.Text = sTemp

   Else
   'Unsuccessfully completed.
      sTemp = "Iris_Verify method is unsuccessfully completed."
      For Each oError In m_oCn.Errors
         sTemp = sTemp & vbCrLf & "[Database.Errors]"
         'Get error information from Error object
         sTemp = sTemp & vbCrLf & "Number : " & oError.Number
         sTemp = sTemp & vbCrLf & "Source : " & oError.Source
         sTemp = sTemp & vbCrLf & "Description : " & oError.Description
         sTemp = sTemp & vbCrLf
      Next
      txtResult.Text = sTemp
   End If

   Me.MousePointer = vbDefault
   Exit Sub
VB_Err:
   Me.MousePointer = vbDefault
   MsgBox Err.Description, , Err.Source

End Sub

Private Sub cmdLog_Delete_Click()

   Dim lKind As Long
   Dim lLogType As Long
   Dim ret As Long
   Dim i As Integer
   Dim sTemp As String
   Dim oLog As Object
   Dim oError As Object
   Dim rtn As Long
   Dim nCnt As Long

   On Error GoTo VB_Err

   Me.MousePointer = vbHourglass

   txtResult.Text = ""
```

```vb
If Option1(0).Value = True Then
   lLogType = 0    'Access Log
ElseIf Option1(1).Value = True Then
   lLogType = 1    'Alarm Log
Else
   lLogType = 2    'System Log
End If

If chkLogID.Value = 1 Then
   lKind = 0
Else
   lKind = 1
End If

If lKind = 0 Then
   rtn = m_oCn.Log_Delete(lLogType, lKind, Text1(2).Text, "")
Else
   rtn = m_oCn.Log_Delete(lLogType, lKind, 0, Text1(2).Text)
End If

If rtn = 0 Then
'Successfully completed.
   sTemp = "Log_Delete method is successfully completed." & vbCrLf
Else
'Unsuccessfully completed.
   sTemp = sTemp & "Log_Delete method is unsuccessfully completed."
   For Each oError In m_oCn.Errors
      sTemp = sTemp & vbCrLf & "[Database.Errors]"
      'Get error information from Error object
      sTemp = sTemp & vbCrLf & "Number : " & oError.Number
      sTemp = sTemp & vbCrLf & "Source : " & oError.Source
      sTemp = sTemp & vbCrLf & "Description : " & oError.Description
      sTemp = sTemp & vbCrLf
   Next
End If

txtResult.Text = sTemp

Me.MousePointer = Default

Exit Sub
VB_Err:

Me.MousePointer = vbDefault
MsgBox Err.Description, , Err.Source
```

```vb
End Sub

Private Sub cmdLogEvent_Set_Click()

    Dim rtn As Long
    Dim sTemp As String
    Dim oError As Object

    Set LogEvent = CreateObject("ES300SDK.LogEvent")
    'Set LogEvent object
    rtn = m_oCn.LogEvent_Set(LogEvent)

    If rtn = 0 Then
        'Successfully completed.
        txtResult.Text = "LogEvent_Set method is successfully completed."

    ElseIf rtn <> 0 Then
        'Unsuccessfully completed.
        sTemp = "LogEvent_Set method is unsuccessfully completed."
        For Each oError In m_oCn.Errors
            sTemp = sTemp & vbCrLf & "[Database.Errors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
        Next

        txtResult.Text = sTemp
    End If

End Sub

Private Sub cmdLogEvents_Start_Click()

    Dim rtn As Long
    Dim sTemp As String
    Dim oError As Object
    Dim LogKind As Long

    On Error GoTo VB_Err

    'Start LogEvent
    If Option1(0).Value = True Then
        LogKind = 0
    ElseIf Option1(1).Value = True Then
```

```vb
      LogKind = 1
   Else
      LogKind = 2
   End If

   rtn = m_oCn.LogEvent_Start(LogKind)
   If rtn = 0 Then
      'Successfully completed.
      txtResult.Text = "LogEvent_Start method is successfully completed."

   ElseIf rtn <> 0 Then
      'Unsuccessfully completed.
      sTemp = "LogEvent_Start method is unsuccessfully completed."
      For Each oError In m_oCn.Errors
         sTemp = sTemp & vbCrLf & "[Database.Errors]"
         'Get error information from Error object
         sTemp = sTemp & vbCrLf & "Number : " & oError.Number
         sTemp = sTemp & vbCrLf & "Source : " & oError.Source
         sTemp = sTemp & vbCrLf & "Description : " & oError.Description
         sTemp = sTemp & vbCrLf
      Next
      txtResult.Text = sTemp
   End If

   Exit Sub
VB_Err:
   MsgBox Err.Description, , Err.Source

End Sub

Private Sub cmdLogEvents_Stop_Click()

   Dim rtn As Long
   Dim sTemp As String
   Dim oError As Object
   Dim LogKind As Long

   On Error GoTo VB_Err

   'Stop LogEvent
   If Option1(0).Value = True Then
      LogKind = 0
   ElseIf Option1(1).Value = True Then
      LogKind = 1
   Else
      LogKind = 2
```

```vb
   End If

   rtn = m_oCn.LogEvent_Stop(LogKind)
   If rtn = 0 Then
      'Successfully completed.
      txtResult.Text = "LogEvent_Stop method is successfully completed."

   ElseIf rtn <> 0 Then
      'Unsuccessfully completed.
      sTemp = "LogEvent_Stop method is unsuccessfully completed."
      For Each oError In m_oCn.Errors
         sTemp = sTemp & vbCrLf & "[Database.Errors]"
         'Get error information from Error object
         sTemp = sTemp & vbCrLf & "Number : " & oError.Number
         sTemp = sTemp & vbCrLf & "Source : " & oError.Source
         sTemp = sTemp & vbCrLf & "Description : " & oError.Description
         sTemp = sTemp & vbCrLf
      Next
      txtResult.Text = sTemp
   End If

   Exit Sub
VB_Err:
   MsgBox Err.Description, , Err.Source

End Sub

Private Sub cmdOpen_Click()
   Dim i As Integer
   Dim oError As Object
   Dim rtn As Long
   Dim sTemp As String

   filecounter = 0

   On Error GoTo VB_Err

   Me.MousePointer = vbHourglass

   txtResult.Text = ""

   If m_oCn Is Nothing Then
      'Create Database object
      Set m_oCn = CreateObject("ES300SDK.Database")
   End If
```

```vb
    'Connect to database
    rtn = m_oCn.Connect(Text1(0).Text, Text1(1).Text)

    If rtn = 0 Then
    'Successfully completed.
        sTemp = "Connect method is successfully completed."
        'Get value from Database object
        sTemp = sTemp & vbCrLf & "ConnectUser = " & m_oCn.ConnectUser
        sTemp = sTemp & vbCrLf & "State = " & m_oCn.State
        sTemp = sTemp & vbCrLf & "Version = " & m_oCn.Version
        txtResult.Text = sTemp
    Else
    'Unsuccessfully completed.
        sTemp = "Connect method is unsuccessfully completed."
        For Each oError In m_oCn.Errors
            sTemp = sTemp & vbCrLf & "[Database.Errors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
        Next

        txtResult.Text = sTemp

    End If

    Me.MousePointer = vbDefault

    Exit Sub
VB_Err:
    Me.MousePointer = vbDefault
    MsgBox Err.Description, , Err.Source
End Sub

Private Sub cmdClose_Click()
    Dim rtn As Long
    Dim oError As Object
    Dim sTemp As String

    On Error GoTo VB_Err

    txtResult.Text = ""

    Me.MousePointer = vbHourglass
```

```vb
   'Release database
   rtn = m_oCn.Disconnect

   If rtn = 0 Then
      txtResult.Text = "Disconnect method is successfully completed."
   Else
      sTemp = "Disconnect method is unsuccessfully completed."
      For Each oError In m_oCn.Errors
         sTemp = sTemp & vbCrLf & "[Database.Errors]"
         'Get error information from Error object
         sTemp = sTemp & vbCrLf & "Number : " & oError.Number
         sTemp = sTemp & vbCrLf & "Source : " & oError.Source
         sTemp = sTemp & vbCrLf & "Description : " & oError.Description
         sTemp = sTemp & vbCrLf
      Next

      txtResult.Text = sTemp

   End If

   Me.MousePointer = vbDefault
   Exit Sub
VB_Err:
   Me.MousePointer = vbDefault
   MsgBox Err.Description, , Err.Source
End Sub

Private Sub cmdGet_Logs_Click()

   Dim lAllGet As Long
   Dim lLogType As Long
   Dim ret As Long
   Dim i As Integer
   Dim sTemp As String
   Dim oLog As Object
   Dim oError As Object
   Dim rtn As Long

   On Error GoTo VB_Err

   Me.MousePointer = vbHourglass

   txtResult.Text = ""

   If Option1(0).Value = True Then
      lLogType = 0    'Access Log
```

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```vb
   ElseIf Option1(1).Value = True Then
      lLogType = 1    'Alarm Log
   Else
      lLogType = 2    'System Log
   End If

   If chkAllGet.Value = 0 Then
      lAllGet = 0    'Get log with specified time
   Else
      lAllGet = 1    'Get all log information
   End If

   'Get log information
   'Refer Log collection in database object for log information
   rtn = m_oCn.Log_Get(lLogType, lAllGet, Text1(2).Text)

   If rtn = 0 Then
   'Successfully completed.
      For Each oLog In m_oCn.Logs
         If oLog.LogType = 0 Then
            'Access Log
            sTemp = sTemp & "LogType : " & oLog.LogType & " : Access Log"
         ElseIf oLog.LogType = 1 Then
            'Alarm Log
            sTemp = sTemp & "LogType : " & oLog.LogType & " : Alarm Log"
         Else
            'System Log
            sTemp = sTemp & "LogType : " & oLog.LogType & " : System Log"
         End If
         'Get log information from Log object
         sTemp = sTemp & vbCrLf & "LogID : " & oLog.LogID
         sTemp = sTemp & vbCrLf & "LogTime : " & oLog.LogTime
         If lLogType = 2 Then
            sTemp = sTemp & vbCrLf & "LogCategory : " & oLog.LogCategory
         End If
         sTemp = sTemp & vbCrLf & "LogResult : " & oLog.LogResult
         sTemp = sTemp & vbCrLf & "LogDetailed : " & oLog.LogDetailed
         sTemp = sTemp & vbCrLf & "CameraID : " & oLog.CameraID
         sTemp = sTemp & vbCrLf & "CameraName : " & oLog.CameraName
         sTemp = sTemp & vbCrLf & vbCrLf
         txtResult.Text = sTemp & txtResult.Text
         sTemp = ""
      Next
      txtResult.Text = "Log_Get method is successfully completed." & vbCrLf & vbCrLf
& txtResult.Text
```

```vb
      Else
      'Unsuccessfully completed.
         sTemp = sTemp & "Log_Get method is unsuccessfully completed."
         For Each oError In m_oCn.Errors
            sTemp = sTemp & vbCrLf & "[Database.Errors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
         Next

         txtResult.Text = sTemp

      End If

      Me.MousePointer = Default

      Exit Sub
VB_Err:

      Me.MousePointer = vbDefault
      MsgBox Err.Description, , Err.Source

End Sub

Private Sub cmdSystemLogClear_Click()

      txtSysLogEvents.Text = ""

End Sub

Private Sub cmdUser_Click(Index As Integer)

      Dim i As Integer
      Dim oUser As Object
      Dim oError As Object
      Dim oGroup As Object
      Dim rtn As Long
      Dim sUserID As String
      Dim stempa As String
      Dim sTemp As String

      Me.MousePointer = vbHourglass

      txtResult.Text = ""
```

```vb
Call cmdClear2_Click

Select Case Index
Case 0
   'Get user information
   rtn = m_oCn.User_Get(txtUserID.Text, oUser)

   If rtn = 0 Then

      'Get user information from User objec
      txtUser(0).Text = oUser.UserID
      txtUser(1).Text = oUser.UserName
      txtUser(2).Text = oUser.SiteCode
      txtUser(3).Text = oUser.UserCode
      txtUser(4).Text = oUser.Department
      txtUser(5).Text = oUser.Telephone
      txtUser(6).Text = oUser.Facsimile
      txtUser(7).Text = oUser.Email
      txtUser(8).Text = oUser.Memo
      If oUser.IrisInformation = 0 Then
         lblIrisInfo.Caption = "No iris data"
      Else
         lblIrisInfo.Caption = "Iris data is available"
      End If

      For Each oGroup In oUser.Groups
         'Get group information from Group object
         lstGroup.AddItem oGroup.GroupName
      Next

      If oUser.KanaName <> "" Then
         txtKana.Text = oUser.KanaName
      End If

   End If

Case 1
   'Delete user information
   rtn = m_oCn.User_Delete(txtUserID.Text)

End Select


If rtn = 0 Then
'Successfully completed.
```

```vb
        txtResult.Text = txtResult.Text & cmdUser(Index).Caption & " method is
successfully completed."
    Else
    'Unsuccessfully completed.
        sTemp = cmdUser(Index).Caption & " method is unsuccessfully completed."
        For Each oError In m_oCn.Errors
            sTemp = sTemp & vbCrLf & "[Database.Errors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
        Next

        txtResult.Text = sTemp

    End If

    Set oUser = Nothing

    Me.MousePointer = vbDefault

End Sub

Private Sub cmdAllUser_Get_Click()
    Dim rtn As Long
    Dim oError As Object
    Dim sTemp As String
    Dim oUser As Object
    Dim oGroup As Object
    Dim sTemp2 As String
    Dim nCnt As Long

    txtResult.Text = ""

    Me.MousePointer = vbHourglass

    'Get all user information
    'Refer users collection of database object for obtained information
    rtn = m_oCn.AllUser_Get

    If rtn = 0 Then
    'Successfully completed.
        sTemp = "AllUser_Get method is successfully completed." & vbCrLf
        For Each oUser In m_oCn.Users
            'Get user information from User object
```

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      sTemp = sTemp & vbCrLf & "UserID : " & oUser.UserID
      sTemp = sTemp & vbCrLf & "UserName : " & oUser.UserName
      sTemp = sTemp & vbCrLf & "SiteCode : " & oUser.SiteCode
      sTemp = sTemp & vbCrLf & "UserCode : " & oUser.UserCode
      sTemp = sTemp & vbCrLf & "Department : " & oUser.Department
      sTemp = sTemp & vbCrLf & "Telephone : " & oUser.Telephone
      sTemp = sTemp & vbCrLf & "Facsimile : " & oUser.Facsimile
      sTemp = sTemp & vbCrLf & "Email : " & oUser.Email
      sTemp = sTemp & vbCrLf & "Memo : " & oUser.Memo
      If oUser.IrisInformation = 0 Then
         sTemp2 = "No iris data"
      Else
         sTemp2 = "Iris data is available"
      End If
      sTemp = sTemp & vbCrLf & "IrisInformation : " & oUser.IrisInformation & _
                              "( " & sTemp2 & " )"
      For Each oGroup In oUser.Groups
         'Get group information from Group object
         sTemp = sTemp & vbCrLf & "Groups : " & oGroup.GroupName
      Next
      sTemp = sTemp & vbCrLf

      nCnt = nCnt + 1
      If nCnt = 100 Then
         txtResult.Text = txtResult.Text & sTemp
         sTemp = ""
         nCnt = 0
      End If

   Next

   If m_oCn.Users.Count = 0 Then
      txtResult.Text = "Nothing"
   Else
      txtResult.Text = txtResult.Text & sTemp
   End If
Else
'Unsuccessfully completed.
   sTemp = "AllUser_Get method is unsuccessfully completed."
   For Each oError In m_oCn.Errors
      sTemp = sTemp & vbCrLf & "[Database.Errors]"
      'Get error information from Error object
      sTemp = sTemp & vbCrLf & "Number : " & oError.Number
      sTemp = sTemp & vbCrLf & "Source : " & oError.Source
      sTemp = sTemp & vbCrLf & "Description : " & oError.Description
      sTemp = sTemp & vbCrLf
```

```
      Next

      txtResult.Text = sTemp

   End If

   Me.MousePointer = vbDefault

End Sub

Private Sub cmdIris_Click(Index As Integer)

   Dim oError As Object
   Dim rtn As Long
   Dim sUserID As String
   Dim lFileNumber As Long
   Dim bData() As Byte
   Dim sTemp As String
   Dim sFileName_l As String
   Dim sFileName_r As String

   Me.MousePointer = vbHourglass

   txtResult.Text = ""

   sFileName_l = App.Path & "\image_l.jpeg"
   sFileName_r = App.Path & "\image_r.jpeg"

   If Index = 0 Or Index = 1 Or Index = 2 Then
      If imgIris(0).Picture <> 0 Then
         imgIris(0).Picture = LoadPicture()
      End If
      lblDate(0).Caption = ""
      lblHD(0).Caption = ""
      If Len(Dir$(sFileName_l)) <> 0 Then
         Kill (sFileName_l)
      End If
   End If
   If Index = 0 Or Index = 1 Or Index = 3 Then
      If imgIris(1).Picture <> 0 Then
         imgIris(1).Picture = LoadPicture()
      End If
      lblDate(1).Caption = ""
      lblHD(1).Caption = ""
      If Len(Dir$(sFileName_r)) <> 0 Then
         Kill (sFileName_r)
```

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        End If
End If

Select Case Index

Case 0
   txtUser(0).Text = txtUserID.Text

   'Get iris data
   rtn = m_oCn.Iris_Get(txtUserID.Text, m_oIris)

   If rtn = 0 Then
   'Successfully completed.

      'Display left iris image from Iris object
      If m_oIris.Left_File_Size <> 0 Then
         lFileNumber = FreeFile
         Open sFileName_l For Binary Access Write As lFileNumber
         bData = m_oIris.Left_Iris_Image_Data
         Put lFileNumber, , bData

         imgIris(0).Picture = LoadPicture(sFileName_l)
         Close lFileNumber
      End If
      'Display left iris capturing time and date from Iris object
      lblDate(0).Caption = m_oIris.Left_CaptureDate

      If m_oIris.Left_Iris_Flag = 1 Then
         If m_oIris.Left_HD = 0 Then
            lblHD(0).Caption = "Excellent"
         Else
            lblHD(0).Caption = "Good"
         End If
      End If

      'Display right iris image from Iris object
      If m_oIris.Right_File_Size <> 0 Then
         lFileNumber = FreeFile
         Open sFileName_r For Binary Access Write As lFileNumber
         bData = m_oIris.Right_Iris_Image_Data
         Put lFileNumber, , bData

         imgIris(1).Picture = LoadPicture(sFileName_r)
         Close lFileNumber
      End If
      'Display right iris capturing time and date from Iris object
```

```vb
        lblDate(1).Caption = m_oIris.Right_CaptureDate
        If m_oIris.Right_Iris_Flag = 1 Then
           If m_oIris.Right_HD = 0 Then
              lblHD(1).Caption = "Excellent"
           Else
              lblHD(1).Caption = "Good"
           End If
        End If

     End If

  Case 1
     'Delete iris data
     rtn = m_oCn.Iris_Clear(txtUserID.Text)

  Case 2
     'Delete left iris data
     rtn = m_oCn.Iris_ClearLeft(txtUserID.Text)

  Case 3
     'Delete right iris data
     rtn = m_oCn.Iris_ClearRight(txtUserID.Text)

End Select

If rtn = 0 Then
'Successfully completed.
   txtResult.Text = cmdIris(Index).Caption & " method is successfully completed."

Else
'Unsuccessfully completed.
   sTemp = cmdIris(Index).Caption & " method is unsuccessfully completed."
   For Each oError In m_oCn.Errors
      sTemp = sTemp & vbCrLf & "[Database.Errors]"
      'Get error information from Error object
      sTemp = sTemp & vbCrLf & "Number : " & oError.Number
      sTemp = sTemp & vbCrLf & "Source : " & oError.Source
      sTemp = sTemp & vbCrLf & "Description : " & oError.Description
      sTemp = sTemp & vbCrLf
   Next

   txtResult.Text = sTemp

End If

Me.MousePointer = vbDefault
```

```
End Sub

Private Sub cmdAddUpUser_Click(Index As Integer)
    Dim oGroup As Object
    Dim i As Integer
    Dim oUser As Object
    Dim oError As Object
    Dim rtn As Long
    Dim sTemp As String

    On Error GoTo VB_Err

    Me.MousePointer = vbHourglass

    txtResult.Text = ""

    'Create User object
    Set oUser = CreateObject("ES300SDK.User")

    'Set user information in User object
    oUser.UserID = txtUser(0).Text
    oUser.UserName = txtUser(1).Text
    oUser.SiteCode = txtUser(2).Text
    oUser.UserCode = txtUser(3).Text
    oUser.Department = txtUser(4).Text
    oUser.Telephone = txtUser(5).Text
    oUser.Facsimile = txtUser(6).Text
    oUser.Email = txtUser(7).Text
    oUser.Memo = txtUser(8).Text

    If txtKana.Text <> "" Then oUser.KanaName = txtKana.Text

    'Set group information in Group object
    For i = 1 To lstGroup.ListCount
        Set oGroup = CreateObject("ES300SDK.Group")
        oGroup.GroupName = lstGroup.List(i - 1)
        oUser.Groups.Add oGroup
    Next i

    Select Case Index
    Case 0
        'New user registration
        rtn = m_oCn.User_Add(oUser)

    Case 1
        'Update user information
```

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      rtn = m_oCn.User_Update(oUser)

   End Select

   If rtn = 0 Then
   'Successfully completed.
      txtResult.Text = cmdAddUpUser(Index).Caption & " method is successfully
completed."

   ElseIf rtn = -2 Then
   'Caution!
   'User information is newly registered or updated.
      sTemp = cmdAddUpUser(Index).Caption & " method is successfully completed."

      For Each oError In m_oCn.Errors
         sTemp = sTemp & vbCrLf & "[Database.Errors]"
         'Get error information from Error object
         sTemp = sTemp & vbCrLf & "Number : " & oError.Number
         sTemp = sTemp & vbCrLf & "Source : " & oError.Source
         sTemp = sTemp & vbCrLf & "Description : " & oError.Description
         sTemp = sTemp & vbCrLf
      Next

      txtResult.Text = sTemp

   Else
   'Unsuccessfully completed.
      sTemp = cmdAddUpUser(Index).Caption & " method is unsuccessfully completed."
      For Each oError In m_oCn.Errors
         sTemp = sTemp & vbCrLf & "[Database.Errors]"
         'Get error information from Error object
         sTemp = sTemp & vbCrLf & "Number : " & oError.Number
         sTemp = sTemp & vbCrLf & "Source : " & oError.Source
         sTemp = sTemp & vbCrLf & "Description : " & oError.Description
         sTemp = sTemp & vbCrLf
      Next

      txtResult.Text = sTemp

   End If

   Set oGroup = Nothing
   Set oUser = Nothing

   Me.MousePointer = vbDefault
   Exit Sub
```

```vb
VB_Err:
    Me.MousePointer = vbDefault
    MsgBox Err.Description, , Err.Source
End Sub

Private Sub cmdClear2_Click()

    Dim nRemoveNum As Integer
    Dim i As Integer

    Me.MousePointer = vbHourglass

    txtUser(0).Text = ""
    txtUser(1).Text = ""
    txtUser(2).Text = ""
    txtUser(3).Text = ""
    txtUser(4).Text = ""
    txtUser(5).Text = ""
    txtUser(6).Text = ""
    txtUser(7).Text = ""
    txtUser(8).Text = ""

    If imgIris(0).Picture <> 0 Then
        imgIris(0).Picture = LoadPicture()
        Kill App.Path & "\image_l.jpeg"
    End If
    If imgIris(1).Picture <> 0 Then
        imgIris(1).Picture = LoadPicture()
        Kill App.Path & "\image_r.jpeg"
    End If

    lblDate(0).Caption = ""
    lblDate(1).Caption = ""
    lblHD(0).Caption = ""
    lblHD(1).Caption = ""

    lblCapture.Caption = ""
    lblIrisInfo.Caption = ""

    For i = 0 To lstGroup.ListCount - 1 - nRemoveNum
        lstGroup.RemoveItem (i - nRemoveNum)
        nRemoveNum = nRemoveNum + 1
    Next

    Me.MousePointer = vbDefault
```

```
End Sub

Private Sub cmdCaptureIris_Click()
    Dim oError As Object
    Dim lFileNumber As Long
    Dim bData() As Byte
    Dim rtn As Long
    Dim OnImage As Long
    Dim sTemp As String

    On Error GoTo VB_Err

    Me.MousePointer = vbHourglass

    txtResult.Text = ""

    If chkPicture.Value = 1 Then
        OnImage = 1
    Else
        OnImage = 0
    End If

    'Start iris image capturing
    'This method is asynchronous.
    'Refer StillCapture in database object for image condition.
    rtn = m_oCn.Capture(OnImage)

    If rtn = 0 Then
    'Successfully completed.
        txtResult.Text = "Capture method is successfully completed."

        lblCapture.Caption = "Iris image capturing"
        tmrCaptureStatus.Enabled = True

    Else
    'Unsuccessfully completed.
        sTemp = "Capture method is unsuccessfully completed."
        For Each oError In m_oCn.Errors
            sTemp = sTemp & vbCrLf & "[Database.Errors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
        Next
```

```
          txtResult.Text = sTemp

      End If


    Me.MousePointer = vbDefault
    Exit Sub
VB_Err:
    Me.MousePointer = vbDefault
    MsgBox Err.Description, , Err.Source
End Sub


Private Sub cmdCapture_Cancel_Click()
    Dim rtn
    Dim oError As Object
    Dim sTemp As String

    Me.MousePointer = vbHourglass

    txtResult.Text = ""

    'Cancel iris image capturing
    'This method is asynchronous.
    'Refer StillCapture in database object for image condition.
    rtn = m_oCn.Capture_Cancel

    If rtn = 0 Then
    'Successfully completed.
        txtResult.Text = "Capture_Cancel method is successfully completed."
    Else
    'Unsuccessfully completed.
        sTemp = "Capture_Cancel method is unsuccessfully completed."
        For Each oError In m_oCn.Errors
            sTemp = sTemp & vbCrLf & "[Database.Errors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
        Next

        txtResult.Text = sTemp

    End If

    Me.MousePointer = vbDefault
```

```
End Sub

Private Sub cmdAddUp_Iris_Click()
    Dim rtn As Long
    Dim oError As Object
    Dim sTemp As String

    On Error GoTo VB_Err

    Me.MousePointer = vbHourglass

    txtResult.Text = ""

    If m_oIris Is Nothing Then
        'Create Iris object
        Set m_oIris = CreateObject("ES300SDK.Iris")
    End If

    m_oIris.UserID = txtUser(0).Text

    'Set iris data
    rtn = m_oCn.Iris_Set(m_oIris)

    If rtn = 0 Then
    'Successfully completed.
        txtResult.Text = "Iris_Set method is successfully completed."
    Else
    'Unsuccessfully completed.
        sTemp = "Iris_Set method is unsuccessfully completed."
        For Each oError In m_oCn.Errors
            sTemp = sTemp & vbCrLf & "[Database.Errors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
        Next

        txtResult.Text = sTemp

    End If

    Me.MousePointer = vbDefault

    Exit Sub
VB_Err:
```

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    Me.MousePointer = vbDefault
    MsgBox Err.Description, , Err.Source
End Sub

Private Sub cmdGet_Group_Click()
    Dim oError As Object
    Dim rtn As Long
    Dim nRemoveNum As Long
    Dim oGroup As Object
    Dim i As Integer
    Dim sTemp As String
    Dim oCamera As Object

    Me.MousePointer = vbHourglass

    txtResult.Text = ""

    'Get group information
    'Refer Group collection in database object for group information
    rtn = m_oCn.Group_Get

    If rtn = 0 Then
    'Successfully completed.

        sTemp = "Group_Get method is successfully completed." & vbCrLf

        lstAllGroups.Clear

        'Get group information from Group object
        For Each oGroup In m_oCn.Groups
            lstAllGroups.AddItem oGroup.GroupName
            sTemp = sTemp & vbCrLf & "GroupName : " & oGroup.GroupName
            For Each oCamera In oGroup.Cameras
                sTemp = sTemp & vbCrLf & "  CameraID : " & oCamera.CameraID
            Next
        Next

        txtResult.Text = sTemp

    Else
    'Unsuccessfully completed.
        sTemp = "Group_Get method is unsuccessfully completed."
        For Each oError In m_oCn.Errors
            sTemp = sTemp & vbCrLf & "[Database.Errors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
```

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            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
        Next

        txtResult.Text = sTemp

    End If

    Me.MousePointer = vbDefault

End Sub

Private Sub cmdCaptureIris_Get_Click()
    Dim rtn As Long
    Dim oError As Object
    Dim lFileNumber As Long
    Dim bData() As Byte
    Dim sTemp As String
    Dim sFileName_l As String
    Dim sFileName_r As String
    Dim sIC_l As String
    Dim sIC_r As String
    Dim tester As Variant
    Dim byter As Variant
    Dim i As Integer

    sIC_l = "C:\Brady Thesis\IrisData\" & txtUser(1).Text & "_l." & filecounter & ".dat"
    sIC_r = "C:\Brady Thesis\IrisData\" & txtUser(1).Text & "_r." & filecounter & ".dat"

    filecounter = filecounter + 1

    Me.MousePointer = vbHourglass

    txtResult.Text = ""

    If imgIris(0).Picture <> 0 Then
        imgIris(0).Picture = LoadPicture()
    End If

    If imgIris(1).Picture <> 0 Then
        imgIris(1).Picture = LoadPicture()
    End If

    lblHD(0).Caption = ""
    lblHD(1).Caption = ""
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lblDate(0).Caption = ""
lblDate(1).Caption = ""

sFileName_l = App.Path & "\image_l.jpeg"
sFileName_r = App.Path & "\image_r.jpeg"

If Len(Dir$(sFileName_l)) <> 0 Then
    Kill (sFileName_l)
End If

If Len(Dir$(sFileName_r)) <> 0 Then
    Kill (sFileName_r)
End If

'Get image capturing result
rtn = m_oCn.CaptureIris_Get(m_oIris)

If rtn = 0 Then
    txtResult.Text = "CaptureIris_Get method is successfully completed."

    If rtn = 0 Then

        'Display left iris image from Iris object
        If m_oIris.Left_File_Size <> 0 Then
            lFileNumber = FreeFile
            Open sFileName_l For Binary Access Write As lFileNumber
            bData = m_oIris.Left_Iris_Image_Data
            Put lFileNumber, , bData

            imgIris(0).Picture = LoadPicture(sFileName_l)
            Close lFileNumber
        End If

        'Display left iris capturing time and date from Iris object
        lblDate(0).Caption = m_oIris.Left_CaptureDate

        txtResult.Text = 0

        If m_oIris.Left_Iris_Flag = 1 Then
'-----------------------------------------------
            tester = m_oIris.Left_ShortIris
            Call mFileSysObj.CreateTextFile(sIC_l)
            Set mFile = mFileSysObj.GetFile(sIC_l)
            Set mTxtStream = mFile.OpenAsTextStream(ForWriting)

            For Each byter In tester
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            Call mTxtStream.Write(byter)
            Call mTxtStream.Write(" ")
          Next

          Call mTxtStream.WriteLine("")

          mTxtStream.Close
'---------------------------------------------
          If m_oIris.Left_HD = 0 Then
            lblHD(0).Caption = "Excellent"
          Else
            lblHD(0).Caption = "Good"
          End If
        End If

        'Display right iris image from Iris object
        If m_oIris.Right_File_Size <> 0 Then
          lFileNumber = FreeFile
          Open sFileName_r For Binary Access Write As lFileNumber
          bData = m_oIris.Right_Iris_Image_Data
          Put lFileNumber, , bData

          imgIris(1).Picture = LoadPicture(sFileName_r)
          Close lFileNumber
        End If

        'Display right iris capturing time and date from Iris object
        lblDate(1).Caption = m_oIris.Right_CaptureDate

        If m_oIris.Right_Iris_Flag = 1 Then
'---------------------------------------------
          tester = m_oIris.Right_ShortIris
          Call mFileSysObj.CreateTextFile(sIC_r)
          Set mFile = mFileSysObj.GetFile(sIC_r)
          Set mTxtStream = mFile.OpenAsTextStream(ForWriting)

          For Each byter In tester
            Call mTxtStream.Write(byter)
            Call mTxtStream.Write(" ")
          Next

          Call mTxtStream.WriteLine("")

          mTxtStream.Close
'---------------------------------------------
          If m_oIris.Right_HD = 0 Then
```

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            lblHD(1).Caption = "Excellent"
         Else
            lblHD(1).Caption = "Good"
         End If
      End If

   End If

   If m_oCn.StillCapturing = -3 Then
      If m_oIris.Left_Iris_Flag = 0 Then
         txtResult.Text = txtResult.Text & vbCrLf & _
                   "Iris.Left_ErrorMessage : " & m_oIris.Left_ErrorMessage
      End If

      If m_oIris.Right_Iris_Flag = 0 Then
         txtResult.Text = txtResult.Text & vbCrLf & _
                   "Iris.Right_ErrorMessage : " & m_oIris.Right_ErrorMessage
      End If
   End If

 Else
    sTemp = "CaptureIris_Get method is unsuccessfully completed."
    For Each oError In m_oCn.Errors
       sTemp = sTemp & vbCrLf & "[Database.Errors]"
       'Get error information from Error object
       sTemp = sTemp & vbCrLf & "Number : " & oError.Number
       sTemp = sTemp & vbCrLf & "Source : " & oError.Source
       sTemp = sTemp & vbCrLf & "Description : " & oError.Description
       sTemp = sTemp & vbCrLf
    Next

    txtResult.Text = sTemp

 End If

 Me.MousePointer = vbDefault

End Sub

Private Sub cmdDistribute_Click()

   Dim rtn As Long
   Dim oError As Object
   Dim sTemp As String

   Me.MousePointer = vbHourglass
```

```
   txtResult.Text = ""
   lblDistribute.Caption = ""

   'Distribute Iris data
   'This method is asynchronous.
   'Refer StillDistributing in database object for distributing condition.
   rtn = m_oCn.Distribute

   If rtn = 0 Then
   'Successfully completed.
      txtResult.Text = cmdDistribute.Caption & " method is successfully completed."

      tmrDistributeStatus.Enabled = True

   Else
   'Unsuccessfully completed.
      sTemp = "Distribute method is unsuccessfully completed."
      For Each oError In m_oCn.Errors
         sTemp = sTemp & vbCrLf & "[Database.Errors]"
         'Get error information from Error object
         sTemp = sTemp & vbCrLf & "Number : " & oError.Number
         sTemp = sTemp & vbCrLf & "Source : " & oError.Source
         sTemp = sTemp & vbCrLf & "Description : " & oError.Description
         sTemp = sTemp & vbCrLf
      Next

      txtResult.Text = sTemp

   End If

   Me.MousePointer = vbDefault

End Sub

Private Sub cmdGroupAdd_Click()

   Dim i As Integer
   Dim j As Integer

   For i = 0 To lstAllGroups.ListCount - 1
      If lstAllGroups.Selected(i) = True Then
         lstGroup.AddItem lstAllGroups.List(i)
      End If
   Next i

End Sub
```

```vb
Private Sub cmdGroupDel_Click()

    Dim i As Integer
    Dim nCnt As Integer

    nCnt = 0

    For i = 0 To lstGroup.ListCount - 1

        If lstGroup.Selected(nCnt) = True Then
            lstGroup.RemoveItem (nCnt)
            nCnt = nCnt - 1
        End If

        nCnt = nCnt + 1

    Next i

End Sub

Private Sub cmdClear_Click()

    txtResult.Text = ""

End Sub

Private Sub Command1_Click()

    txtCameraName.Text = ""
    txtIPAddress.Text = ""
    txtRecogMode = ""
    txtServerMode.Text = ""
    txtAudioMode.Text = ""
    txtGuidance.Text = ""
    txtOutput1.Text = ""
    txtOutput2.Text = ""
    txtLive.Text = ""
    txtSiteCode.Text = ""
    txtUserCode.Text = ""
    txtPulseWidth.Text = ""
    txtPulseInterval.Text = ""
    txtMode.Text = ""
    txtState.Text = ""


End Sub
```

```vb
Private Sub Command2_Click()
    lstAllGroups.Clear
End Sub

Private Sub EnrollCamera_Click()

    Dim rtn As Long
    Dim oError As Object
    Dim sTemp As String
    Dim sCameraID As String

    On Error GoTo VB_Err

    txtResult.Text = ""

    Me.MousePointer = vbHourglass

    sCameraID = txtCameraID.Text

    'EnrollCamera
    rtn = m_oCn.EnrollCamera(sCameraID)

    If rtn = 0 Then
        txtResult.Text = "EnrollCamera method is successfully completed."
    Else
        sTemp = "EnrollCamera method is unsuccessfully completed."
        For Each oError In m_oCn.Errors
            sTemp = sTemp & vbCrLf & "[Database.Errors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
        Next

        txtResult.Text = sTemp

    End If

    Me.MousePointer = vbDefault
    Exit Sub

VB_Err:
    Me.MousePointer = vbDefault
    MsgBox Err.Description, , Err.Source
End Sub
```

```vb
Private Sub Form_Load()

    Me.Top = 0
    Me.Left = 0

    'Create Database object
    Set m_oCn = CreateObject("ES300SDK.Database")

End Sub

Private Sub Form_Unload(Cancel As Integer)

    Dim sFileName_l As String
    Dim sFileName_r As String

    'Delete Database object
    Set m_oCn = Nothing

    sFileName_l = App.Path & "\image_l.jpeg"
    sFileName_r = App.Path & "\image_r.jpeg"

    If Len(Dir$(sFileName_l)) <> 0 Then
        Kill (sFileName_l)
    End If

    If Len(Dir$(sFileName_r)) <> 0 Then
        Kill (sFileName_r)
    End If

End Sub

Private Sub LogEvent_AccessLog(ByVal oLog As Object)

    Dim sTemp As String

    'New access log is found

    sTemp = sTemp & "LogType : " & oLog.LogType & " : Access Log"
    sTemp = sTemp & vbCrLf & "LogID : " & oLog.LogID
    sTemp = sTemp & vbCrLf & "LogTime : " & oLog.LogTime
    sTemp = sTemp & vbCrLf & "LogResult : " & oLog.LogResult
    sTemp = sTemp & vbCrLf & "LogDetailed : " & oLog.LogDetailed
    sTemp = sTemp & vbCrLf & "CameraID : " & oLog.CameraID
    sTemp = sTemp & vbCrLf & "CameraName : " & oLog.CameraName

    txtAccLogEvents.Text = sTemp & vbCrLf & vbCrLf & txtAccLogEvents.Text
```

End Sub

Private Sub LogEvent_AlarmLog(ByVal oLog As Object)

   Dim sTemp As String

   'New alarm log is found

   sTemp = sTemp & "LogType : " & oLog.LogType & " : Alarm Log"
   sTemp = sTemp & vbCrLf & "LogID : " & oLog.LogID
   sTemp = sTemp & vbCrLf & "LogTime : " & oLog.LogTime
   sTemp = sTemp & vbCrLf & "LogResult : " & oLog.LogResult
   sTemp = sTemp & vbCrLf & "LogDetailed : " & oLog.LogDetailed
   sTemp = sTemp & vbCrLf & "CameraID : " & oLog.CameraID
   sTemp = sTemp & vbCrLf & "CameraName : " & oLog.CameraName

   txtAlmLogEvents.Text = sTemp & vbCrLf & vbCrLf & txtAlmLogEvents.Text

End Sub

Private Sub LogEvent_SystemLog(ByVal oLog As Object)

   Dim sTemp As String

   'New system log is found

   sTemp = sTemp & "LogType : " & oLog.LogType & " : System Log"
   sTemp = sTemp & vbCrLf & "LogID : " & oLog.LogID
   sTemp = sTemp & vbCrLf & "LogTime : " & oLog.LogTime
   sTemp = sTemp & vbCrLf & "LogCategory : " & oLog.LogCategory
   sTemp = sTemp & vbCrLf & "LogResult : " & oLog.LogResult
   sTemp = sTemp & vbCrLf & "LogDetailed : " & oLog.LogDetailed
   sTemp = sTemp & vbCrLf & "CameraID : " & oLog.CameraID
   sTemp = sTemp & vbCrLf & "CameraName : " & oLog.CameraName

   txtSysLogEvents.Text = sTemp & vbCrLf & vbCrLf & txtSysLogEvents.Text

End Sub

Private Sub tmrCaptureStatus_Timer()

   Dim oError As Object
   Dim sTemp As String

```vbnet
If m_oCn Is Nothing Then
    tmrCaptureStatus.Enabled = False
    Exit Sub
End If

'Status Monitoring in StillCapturing property of Database object
'Iris image capturing (1)
'Cancel command received (2)
'Iris image capturing successfully completed (0)
'Iris image capturing unsuccessfully completed (-1)
'Iris image capturing cancelled (-2)
'Failure in Iris image capturing (-3)
If m_oCn.StillCapturing <> 1 Then

    Select Case m_oCn.StillCapturing
    Case 2
    'Cancel iris image capturing.
        lblCapture.Caption = "Cancel iris image capturing."
    Case 0
    'Iris image capturing completed.
        lblCapture.Caption = "Iris image capturing completed."
        tmrCaptureStatus.Enabled = False
        'Get image capturing result by CaptureIris_Get method
    Case -1
    'Unsuccessfully completed.
        lblCapture.Caption = "Unsuccessfully completed."
        tmrCaptureStatus.Enabled = False

        txtResult.Text = ""

        For Each oError In m_oCn.CaptureErrors
            sTemp = sTemp & "[Database.CaptureErrors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
        Next

        txtResult.Text = sTemp

    Case -2
    'Iris image capturing cancelled.
        lblCapture.Caption = "Iris image capturing cancelled."
        tmrCaptureStatus.Enabled = False
    Case -3
```

```vb
        'Failure in iris image capturing.
           lblCapture.Caption = "Failure in iris image capturing."
           tmrCaptureStatus.Enabled = False
           'Get image capturing result by CaptureIris_Get method
           'Refer error information with m_Left_ErrMsg property and m_Right_ErrMsg
property in Iris object
       End Select

    End If

End Sub

Private Sub tmrDistributeStatus_Timer()

    Dim oError As Object
    Dim sTemp As String

    If m_oCn Is Nothing Then
       tmrDistributeStatus.Enabled = False
       Exit Sub
    End If

    'Status Monitoring in StillDistributing property of Database object
    'Data distributing(1)
    'Data distribution successfully completed (0)
    'Data distribution unsuccessfully completed (-1)
    'No data distributed (-2)

    If m_oCn.StillDistributing <> 1 Then

       Select Case m_oCn.StillDistributing
       Case 0
       'Data distribution completed.
          lblDistribute.Caption = "Data distribution completed."
       Case -1
       'Unsuccessfully completed.
          lblDistribute.Caption = "Unsuccessfully completed."

          txtResult.Text = ""

          For Each oError In m_oCn.DistributeErrors
             sTemp = sTemp & "[Database.DistributeErrors]"
             'Get error information from Error object
             sTemp = sTemp & vbCrLf & "Number : " & oError.Number
             sTemp = sTemp & vbCrLf & "Source : " & oError.Source
             sTemp = sTemp & vbCrLf & "Description : " & oError.Description
```

```
            sTemp = sTemp & vbCrLf
        Next

        txtResult.Text = sTemp

    Case -2
    'No data distributed.
        lblDistribute.Caption = "No data distributed."
    End Select

        tmrDistributeStatus.Enabled = False
    Else
        lblDistribute.Caption = "Data distributing."
    End If

End Sub

Private Sub cmdAllCamera_Get_Click()

    Dim rtn As Long
    Dim sTemp As String
    Dim oError As Object
    Dim oCamera As Object
    Dim oGroup As Object

    On Error GoTo VB_Err

    Me.MousePointer = vbHourglass
    rtn = m_oCn.AllCamera_Get()

    If rtn = 0 Then
        txtResult.Text = "AllCamera_Get method is successfully completed."
        For Each oCamera In m_oCn.Cameras
          'Get camera information from Camera object
          sTemp = sTemp & vbCrLf & "CameraID : " & oCamera.CameraID
          sTemp = sTemp & vbCrLf & "CameraName : " & oCamera.CameraName
          sTemp = sTemp & vbCrLf & "IPAddress : " & oCamera.IPAddress
          sTemp = sTemp & vbCrLf & "RecognitionMode : " &
oCamera.RecognitionMode
          sTemp = sTemp & vbCrLf & "ServerCertification : " &
oCamera.ServerCertification
          sTemp = sTemp & vbCrLf & "AudioMode : " & oCamera.AudioMode
          sTemp = sTemp & vbCrLf & "GuidanceLanguage : " &
oCamera.GuidanceLanguage
          sTemp = sTemp & vbCrLf & "Output1 : " & oCamera.Output1
          sTemp = sTemp & vbCrLf & "Output2 : " & oCamera.Output2
```

```vb
            sTemp = sTemp & vbCrLf & "LiveIndicator : " & oCamera.LiveIndicator
            sTemp = sTemp & vbCrLf & "SiteCode : " & oCamera.SiteCode
            sTemp = sTemp & vbCrLf & "UserCode : " & oCamera.UserCode
            sTemp = sTemp & vbCrLf & "PulseWidth : " & oCamera.PulseWidth
            sTemp = sTemp & vbCrLf & "PulseInterval : " & oCamera.PulseInterval
            sTemp = sTemp & vbCrLf & "ActionMode : " & oCamera.ActionMode
            sTemp = sTemp & vbCrLf & "State : " & oCamera.State
            For Each oGroup In oCamera.Groups
                sTemp = sTemp & vbCrLf & "Group : " & oGroup.GroupName
            Next oGroup
            sTemp = sTemp & vbCrLf
        Next oCamera
        If m_oCn.Cameras.Count = 0 Then
            txtResult.Text = "Nothing"
        Else
            txtResult.Text = txtResult.Text & sTemp
        End If
    Else
        sTemp = "AllCamera_Get method is unsuccessfully completed."
        For Each oError In m_oCn.Errors
            sTemp = sTemp & vbCrLf & "[Database.Errors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
        Next

        txtResult.Text = sTemp

    End If

    Me.MousePointer = vbDefault
    Exit Sub

VB_Err:
    Me.MousePointer = vbDefault
    MsgBox Err.Description, , Err.Source
End Sub

Private Sub cmdCamera_Delete_Click()

    Dim rtn As Long
    Dim sTemp As String
    Dim oError As Object
```

```vb
On Error GoTo VB_Err

Me.MousePointer = vbHourglass
rtn = m_oCn.Camera_Delete(txtCameraID.Text)

If rtn = 0 Then
   txtResult.Text = "Camera_Delete method is successfully completed."
Else
   sTemp = "Camera_Delete method is unsuccessfully completed."
   For Each oError In m_oCn.Errors
      sTemp = sTemp & vbCrLf & "[Database.Errors]"
      'Get error information from Error object
      sTemp = sTemp & vbCrLf & "Number : " & oError.Number
      sTemp = sTemp & vbCrLf & "Source : " & oError.Source
      sTemp = sTemp & vbCrLf & "Description : " & oError.Description
      sTemp = sTemp & vbCrLf
   Next

   txtResult.Text = sTemp

End If

Me.MousePointer = vbDefault
Exit Sub

VB_Err:
   Me.MousePointer = vbDefault
   MsgBox Err.Description, , Err.Source
End Sub

Private Sub txtCamera_Start_Click()

   Dim rtn As Long
   Dim oError As Object
   Dim sTemp As String
   Dim sCameraID As String

   On Error GoTo VB_Err

   txtResult.Text = ""

   Me.MousePointer = vbHourglass

   sCameraID = txtCameraID.Text

   'Camera_Start
```

```
      rtn = m_oCn.Camera_Start(sCameraID)

      If rtn = 0 Then
         txtResult.Text = "Camera_Start method is successfully completed."
      Else
         sTemp = "Camera_Start method is unsuccessfully completed."
         For Each oError In m_oCn.Errors
            sTemp = sTemp & vbCrLf & "[Database.Errors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
         Next

         txtResult.Text = sTemp

      End If

      Me.MousePointer = vbDefault
      Exit Sub

VB_Err:
      Me.MousePointer = vbDefault
      MsgBox Err.Description, , Err.Source

End Sub

Private Sub txtCamera_Stop_Click()

      Dim rtn As Long
      Dim oError As Object
      Dim sTemp As String
      Dim sCameraID As String

      On Error GoTo VB_Err

      txtResult.Text = ""

      Me.MousePointer = vbHourglass

      sCameraID = txtCameraID.Text

      'Camera_Stop
      rtn = m_oCn.Camera_Stop(sCameraID)
```

```
      If rtn = 0 Then
         txtResult.Text = "Camera_Stop method is successfully completed."
      Else
         sTemp = "Camera_Stop method is unsuccessfully completed."
         For Each oError In m_oCn.Errors
            sTemp = sTemp & vbCrLf & "[Database.Errors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
         Next

         txtResult.Text = sTemp

      End If

      Me.MousePointer = vbDefault
      Exit Sub

VB_Err:
      Me.MousePointer = vbDefault
      MsgBox Err.Description, , Err.Source

End Sub


Private Sub cmdCamera_Update_Click()

      Dim oCamera As Object
      Dim rtn As Long
      Dim sTemp As String
      Dim oError As Object
      Dim nMac As Long

      On Error GoTo VB_Err

      Me.MousePointer = vbHourglass

      Set oCamera = CreateObject("ES300SDK.Camera")

      oCamera.CameraID = txtCameraID.Text
      oCamera.CameraName = txtCameraName.Text
      oCamera.IPAddress = txtIPAddress.Text
      oCamera.RecognitionMode = txtRecogMode.Text
      oCamera.ServerCertification = txtServerMode.Text
```

```
    oCamera.AudioMode = txtAudioMode.Text
    oCamera.GuidanceLanguage = txtGuidance.Text
    oCamera.Output1 = txtOutput1.Text
    oCamera.Output2 = txtOutput2.Text
    oCamera.LiveIndicator = txtLive.Text
    oCamera.SiteCode = txtSiteCode.Text
    oCamera.UserCode = txtUserCode.Text
    oCamera.PulseWidth = txtPulseWidth.Text
    oCamera.PulseInterval = txtPulseInterval.Text

    nMac = chkMac.Value
    rtn = m_oCn.Camera_Update(oCamera, nMac)

    If rtn = 0 Then
       txtResult.Text = "Camera_Update method is successfully completed."
    Else
       sTemp = "Camera_Update method is unsuccessfully completed."
       For Each oError In m_oCn.Errors
          sTemp = sTemp & vbCrLf & "[Database.Errors]"
          'Get error information from Error object
          sTemp = sTemp & vbCrLf & "Number : " & oError.Number
          sTemp = sTemp & vbCrLf & "Source : " & oError.Source
          sTemp = sTemp & vbCrLf & "Description : " & oError.Description
          sTemp = sTemp & vbCrLf
       Next

       txtResult.Text = sTemp

    End If

    Me.MousePointer = vbDefault
    Exit Sub

VB_Err:
    Me.MousePointer = vbDefault
    MsgBox Err.Description, , Err.Source
End Sub


Private Sub cmdGroup_Delete_Click()

    Dim oGroup As Object
    Dim oCamera As Object
    Dim i As Integer
    Dim oUser As Object
    Dim oError As Object
```

```vb
    Dim rtn As Long
    Dim sTemp As String
    Dim sCameraID As String
    Dim pos As Integer

    On Error GoTo VB_Err

    Me.MousePointer = vbHourglass

    txtResult.Text = ""

    'Create Group object
    Set oGroup = CreateObject("ES300SDK.Group")

    'Set group information in Group object
    'group delete
    rtn = m_oCn.Group_Delete(txtGroupName.Text)
    If rtn = 0 Then
    'Successfully completed.
        txtResult.Text = "Group_Delete method is successfully completed."

    Else
    'Unsuccessfully completed.
        sTemp = "Group_Delete method is unsuccessfully completed."
        For Each oError In m_oCn.Errors
            sTemp = sTemp & vbCrLf & "[Database.Errors]"
            'Get error information from Error object
            sTemp = sTemp & vbCrLf & "Number : " & oError.Number
            sTemp = sTemp & vbCrLf & "Source : " & oError.Source
            sTemp = sTemp & vbCrLf & "Description : " & oError.Description
            sTemp = sTemp & vbCrLf
        Next

        txtResult.Text = sTemp

    End If

    Set oGroup = Nothing
    Set oCamera = Nothing

    Me.MousePointer = vbDefault
    Exit Sub
VB_Err:
    Me.MousePointer = vbDefault
    MsgBox Err.Description, , Err.Source
End Sub
```

```vb
Private Sub cmdGroup_Update_Click()

    Dim oGroup As Object
    Dim oCamera As Object
    Dim i As Integer
    Dim oUser As Object
    Dim oError As Object
    Dim rtn As Long
    Dim sTemp As String
    Dim sCameraID As String
    Dim pos As Integer

    On Error GoTo VB_Err

    Me.MousePointer = vbHourglass

    txtResult.Text = ""

    'Create Group object
    Set oGroup = CreateObject("ES300SDK.Group")

    'Set group information in Group object
    'New group registration
    oGroup.GroupName = txtGroupName.Text
    sTemp = txtCameraID_G.Text
    Do While True
       pos = InStr(1, sTemp, ",", vbTextCompare)
       If pos = 0 Then
          Exit Do
       Else
          sCameraID = Mid(sTemp, 1, pos - 1)
          Set oCamera = CreateObject("ES300SDK.Camera")
          oCamera.CameraID = sCameraID
          oGroup.Cameras.Add oCamera
          sTemp = Mid(sTemp, pos + 1, Len(sTemp) - pos)
       End If
    Loop

    rtn = m_oCn.Group_Update(txtMoto.Text, oGroup)
    If rtn = 0 Then
    'Successfully completed.
       txtResult.Text = "Group_Update method is successfully completed."

    Else
    'Unsuccessfully completed.
       sTemp = "Group_Update method is unsuccessfully completed."
```

```vb
    For Each oError In m_oCn.Errors
        sTemp = sTemp & vbCrLf & "[Database.Errors]"
        'Get error information from Error object
        sTemp = sTemp & vbCrLf & "Number : " & oError.Number
        sTemp = sTemp & vbCrLf & "Source : " & oError.Source
        sTemp = sTemp & vbCrLf & "Description : " & oError.Description
        sTemp = sTemp & vbCrLf
    Next

    txtResult.Text = sTemp

  End If

  Set oGroup = Nothing
  Set oCamera = Nothing

  Me.MousePointer = vbDefault
  Exit Sub
VB_Err:
  Me.MousePointer = vbDefault
  MsgBox Err.Description, , Err.Source
      EndSub
```

APPENDIX B. DATA SAMPLES

ID	Light (FC)	Wavelength	Heat (F)	Success/Failure
1	0.3	0	83	1
1	0.3	0	83	1
1	0.3	0	83	1
1	0.3	0	83	1
1	0.3	0	83	1
1	0.3	0	83	1
1	0.3	0	83	1
1	0.3	0	83	1
1	0.3	0	83	1
1	0.3	0	83	1
1	0.3	0	83	1
1	0.3	0	83	1
1	0.3	0	83	1
1	0.3	0	83	1
1	0.3	0	83	1
2	0.3	0	83	1
2	0.3	0	83	0
2	0.3	0	83	0
2	0.3	0	83	0
2	0.3	0	83	1
2	0.3	0	83	1
2	0.3	0	83	1
2	0.3	0	83	1
2	0.3	0	83	1
2	0.3	0	83	1
2	0.3	0	83	1
2	0.3	0	83	1
2	0.3	0	83	1
2	0.3	0	83	1
2	0.3	0	83	1
3	0.3	0	83	1
3	0.3	0	83	0

3	0.3	0	83	1
3	0.3	0	83	0
3	0.3	0	83	1
3	0.3	0	83	1
3	0.3	0	83	0
3	0.3	0	83	0
3	0.3	0	83	0
3	0.3	0	83	1
3	0.3	0	83	1
3	0.3	0	83	1
3	0.3	0	83	1
3	0.3	0	83	1
3	0.3	0	83	1

7	0.3	0	83	1
7	0.3	0	83	1
7	0.3	0	83	0
7	0.3	0	83	1
7	0.3	0	83	0
7	0.3	0	83	1
7	0.3	0	83	0
7	0.3	0	83	1
7	0.3	0	83	0
7	0.3	0	83	1
7	0.3	0	83	0
7	0.3	0	83	0
7	0.3	0	83	1
7	0.3	0	83	0
7	0.3	0	83	0

8	4.5	700	83	0
8	4.5	700	83	1
8	4.5	700	83	0
8	4.5	700	83	1
8	4.5	700	83	0
8	4.5	700	83	1
8	4.5	700	83	1
8	4.5	700	83	0
8	4.5	700	83	1
8	4.5	700	83	0
8	4.5	700	83	1
8	4.5	700	83	1
8	4.5	700	83	1
8	4.5	700	83	1
8	4.5	700	83	1

9	4.5	700	83	1
9	4.5	700	83	1

9	4.5	700	83	1
9	4.5	700	83	1
9	4.5	700	83	0
9	4.5	700	83	0
9	4.5	700	83	1
9	4.5	700	83	1
9	4.5	700	83	1
9	4.5	700	83	0
9	4.5	700	83	1
9	4.5	700	83	0
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41	21	706	83	0
41	21	706	83	1
41	21	706	83	1
41	21	706	83	1
41	21	706	83	1
41	21	706	83	1
41	21	706	83	1
41	21	706	83	1
41	21	706	83	1
41	21	706	83	1

42	21	706	83	0
42	21	706	83	0
42	21	706	83	1

42	21	706	83	0
42	21	706	83	0
42	21	706	83	0
42	21	706	83	0
42	21	706	83	1
42	21	706	83	1
42	21	706	83	1
42	21	706	83	0
42	21	706	83	0
42	21	706	83	0
42	21	706	83	0
42	21	706	83	1

46	65	707	83	1
46	65	707	83	1
46	65	707	83	1
46	65	707	83	1
46	65	707	83	1
46	65	707	83	1
46	65	707	83	1
46	65	707	83	1
46	65	707	83	1
46	65	707	83	1
46	65	707	83	1
46	65	707	83	1
46	65	707	83	1
46	65	707	83	1

47	65	707	83	1
47	65	707	83	1
47	65	707	83	1
47	65	707	83	1
47	65	707	83	1
47	65	707	83	1
47	65	707	83	1
47	65	707	83	1
47	65	707	83	1
47	65	707	83	1
47	65	707	83	1
47	65	707	83	1
47	65	707	83	1
47	65	707	83	1
47	65	707	83	1

48	65	707	83	0
48	65	707	83	1

48	65	707	83	1
48	65	707	83	1
48	65	707	83	1
48	65	707	83	1
48	65	707	83	1
48	65	707	83	1
48	65	707	83	1
48	65	707	83	1
48	65	707	83	1
48	65	707	83	1
48	65	707	83	1
48	65	707	83	1
48	65	707	83	1

53	108	820	83	0
53	108	820	83	1
53	108	820	83	1
53	108	820	83	1
53	108	820	83	1
53	108	820	83	1
53	108	820	83	1
53	108	820	83	1
53	108	820	83	1
53	108	820	83	1
53	108	820	83	1
53	108	820	83	1
53	108	820	83	1
53	108	820	83	1
53	108	820	83	1

54	108	820	83	1
54	108	820	83	1
54	108	820	83	1
54	108	820	83	1
54	108	820	83	1
54	108	820	83	1
54	108	820	83	1
54	108	820	83	1
54	108	820	83	1
54	108	820	83	1
54	108	820	83	1
54	108	820	83	1
54	108	820	83	1
54	108	820	83	1
54	108	820	83	1

55	108	820	83	1

55	108	820	83	1
55	108	820	83	1
55	108	820	83	1
55	108	820	83	1
55	108	820	83	1
55	108	820	83	1
55	108	820	83	1
55	108	820	83	1
55	108	820	83	1
55	108	820	83	1
55	108	820	83	1
55	108	820	83	1
55	108	820	83	1
55	108	820	83	1

59	163	850	83	1
59	163	850	83	1
59	163	850	83	1
59	163	850	83	1
59	163	850	83	1
59	163	850	83	1
59	163	850	83	1
59	163	850	83	1
59	163	850	83	1
59	163	850	83	1
59	163	850	83	1
59	163	850	83	1
59	163	850	83	1
59	163	850	83	1
59	163	850	83	1

60	163	850	83	1
60	163	850	83	1
60	163	850	83	1
60	163	850	83	1
60	163	850	83	1
60	163	850	83	1
60	163	850	83	1
60	163	850	83	1
60	163	850	83	1
60	163	850	83	1
60	163	850	83	1
60	163	850	83	1
60	163	850	83	1
60	163	850	83	1

61	163	850	83	1
61	163	850	83	1
61	163	850	83	1
61	163	850	83	1
61	163	850	83	1
61	163	850	83	1
61	163	850	83	1
61	163	850	83	1
61	163	850	83	1
61	163	850	83	1
61	163	850	83	1
61	163	850	83	1
61	163	850	83	1
61	163	850	83	1
61	163	850	83	1

APPENDIX C. STATISTICAL RESULTS

```
                       The FREQ Procedure

                              ID

                                  Cumulative    Cumulative
      ID     Frequency    Percent   Frequency      Percent
     ----------------------------------------------------------
       1        15         1.59         15          1.59
       2        15         1.59         30          3.17
       3        15         1.59         45          4.76
       4        15         1.59         60          6.35
       5        15         1.59         75          7.94
       6        15         1.59         90          9.52
       7        15         1.59        105         11.11
       8        15         1.59        120         12.70
       9        15         1.59        135         14.29
      10        15         1.59        150         15.87
      11        15         1.59        165         17.46
      12        15         1.59        180         19.05
      13        15         1.59        195         20.63
      14        15         1.59        210         22.22
      15        15         1.59        225         23.81
      16        15         1.59        240         25.40
      17        15         1.59        255         26.98
      18        15         1.59        270         28.57
      19        15         1.59        285         30.16
      20        15         1.59        300         31.75
      21        15         1.59        315         33.33
      22        15         1.59        330         34.92
      23        15         1.59        345         36.51
      24        15         1.59        360         38.10
      25        15         1.59        375         39.68
      26        15         1.59        390         41.27
      27        15         1.59        405         42.86
      28        15         1.59        420         44.44
      29        15         1.59        435         46.03
      30        15         1.59        450         47.62
      31        15         1.59        465         49.21
      32        15         1.59        480         50.79
      33        15         1.59        495         52.38
      34        15         1.59        510         53.97
      35        15         1.59        525         55.56
      36        15         1.59        540         57.14
```

```
37              15              1.59            555             58.73
38              15              1.59            570             60.32
39              15              1.59            585             61.90
40              15              1.59            600             63.49
41              15              1.59            615             65.08
42              15              1.59            630             66.67
43              15              1.59            645             68.25
44              15              1.59            660             69.84
45              15              1.59            675             71.43
```

The FREQ Procedure

ID

```
                                Cumulative      Cumulative
ID      Frequency       Percent     Frequency       Percent
-----------------------------------------------------------
46              15              1.59            690             73.02
47              15              1.59            705             74.60
48              15              1.59            720             76.19
49              15              1.59            735             77.78
50              15              1.59            750             79.37
51              15              1.59            765             80.95
53              15              1.59            780             82.54
54              15              1.59            795             84.13
55              15              1.59            810             85.71
56              15              1.59            825             87.30
57              15              1.59            840             88.89
58              15              1.59            855             90.48
59              15              1.59            870             92.06
60              15              1.59            885             93.65
61              15              1.59            900             95.24
62              15              1.59            915             96.83
63              15              1.59            930             98.41
64              15              1.59            945            100.00
```

Light

```
                                Cumulative      Cumulative
Light   Frequency       Percent     Frequency       Percent
-----------------------------------------------------------
 0.3           105             11.11           105             11.11
 4.5           105             11.11           210             22.22
 5.1           105             11.11           315             33.33
 6.3           105             11.11           420             44.44
   8           105             11.11           525             55.56
  21           105             11.11           630             66.67
  65           105             11.11           735             77.78
 108           105             11.11           840             88.89
 163           105             11.11           945            100.00
```

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The FREQ Procedure

Wavelength

Wavelength	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	105	11.11	105	11.11
700	105	11.11	210	22.22
703	105	11.11	315	33.33
704	105	11.11	420	44.44
705	105	11.11	525	55.56
706	105	11.11	630	66.67
707	105	11.11	735	77.78
820	105	11.11	840	88.89
850	105	11.11	945	100.00

Heat

Heat	Frequency	Percent	Cumulative Frequency	Cumulative Percent
83	945	100.00	945	100.00

S_F

S_F	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	111	11.75	111	11.75
1	834	88.25	945	100.00

The FREQ Procedure

Order

order	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1	63	6.67	63	6.67
2	63	6.67	126	13.33
3	63	6.67	189	20.00
4	63	6.67	252	26.67
5	63	6.67	315	33.33
6	63	6.67	378	40.00
7	63	6.67	441	46.67
8	63	6.67	504	53.33
9	63	6.67	567	60.00
10	63	6.67	630	66.67
11	63	6.67	693	73.33
12	63	6.67	756	80.00
13	63	6.67	819	86.67
14	63	6.67	882	93.33
15	63	6.67	945	100.00

log_light	Frequency	Percent	Cumulative Frequency	Cumulative Percent
-1.203972804	105	11.11	105	11.11
1.5040773968	105	11.11	210	22.22
1.6292405397	105	11.11	315	33.33
1.8405496334	105	11.11	420	44.44
2.0794415417	105	11.11	525	55.56
3.0445224377	105	11.11	630	66.67
4.1743872699	105	11.11	735	77.78
4.6821312271	105	11.11	840	88.89
5.0937502008	105	11.11	945	100.00

wavecat	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	105	11.11	105	11.11
700	630	66.67	735	77.78
800	210	22.22	945	100.00

```
                  The FREQ Procedure

                Table of order by S_F

        Order(order)      S_F(S_F)

        Frequency|
        Percent  |
        Row Pct  |
        Col Pct  |        0|        1|  Total
        ---------+--------+--------+
              1 |      20 |      43 |     63
                |    2.12 |    4.55 |   6.67
                |   31.75 |   68.25 |
                |   18.02 |    5.16 |
        ---------+--------+--------+
              2 |       7 |      56 |     63
                |    0.74 |    5.93 |   6.67
                |   11.11 |   88.89 |
                |    6.31 |    6.71 |
        ---------+--------+--------+
              3 |       8 |      55 |     63
                |    0.85 |    5.82 |   6.67
                |   12.70 |   87.30 |
                |    7.21 |    6.59 |
        ---------+--------+--------+
              4 |       8 |      55 |     63
                |    0.85 |    5.82 |   6.67
                |   12.70 |   87.30 |
                |    7.21 |    6.59 |
        ---------+--------+--------+
              5 |      10 |      53 |     63
                |    1.06 |    5.61 |   6.67
                |   15.87 |   84.13 |
                |    9.01 |    6.35 |
        ---------+--------+--------+
        Total          111      834      945
                     11.75    88.25   100.00
        (Continued)
```

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```
                    The FREQ Procedure

                  Table of order by S_F

         Order(order)      S_F(S_F)

         Frequency|
         Percent  |
         Row Pct  |
         Col Pct  |       0|       1|  Total
         ---------+--------+--------+
                6 |      8 |     55 |     63
                  |   0.85 |   5.82 |   6.67
                  |  12.70 |  87.30 |
                  |   7.21 |   6.59 |
         ---------+--------+--------+
                7 |      6 |     57 |     63
                  |   0.63 |   6.03 |   6.67
                  |   9.52 |  90.48 |
                  |   5.41 |   6.83 |
         ---------+--------+--------+
                8 |      4 |     59 |     63
                  |   0.42 |   6.24 |   6.67
                  |   6.35 |  93.65 |
                  |   3.60 |   7.07 |
         ---------+--------+--------+
                9 |      6 |     57 |     63
                  |   0.63 |   6.03 |   6.67
                  |   9.52 |  90.48 |
                  |   5.41 |   6.83 |
         ---------+--------+--------+
               10 |      5 |     58 |     63
                  |   0.53 |   6.14 |   6.67
                  |   7.94 |  92.06 |
                  |   4.50 |   6.95 |
         ---------+--------+--------+
         Total          111      834      945
                      11.75    88.25   100.00
         (Continued)
```

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```
                The FREQ Procedure

              Table of order by S_F

     order(order)      S_F(S_F)

     Frequency|
     Percent  |
     Row Pct  |
     Col Pct  |       0|       1|  Total
     ---------+--------+--------+
         11   |      5 |     58 |     63
              |   0.53 |   6.14 |   6.67
              |   7.94 |  92.06 |
              |   4.50 |   6.95 |
     ---------+--------+--------+
         12   |      6 |     57 |     63
              |   0.63 |   6.03 |   6.67
              |   9.52 |  90.48 |
              |   5.41 |   6.83 |
     ---------+--------+--------+
         13   |      6 |     57 |     63
              |   0.63 |   6.03 |   6.67
              |   9.52 |  90.48 |
              |   5.41 |   6.83 |
     ---------+--------+--------+
         14   |      8 |     55 |     63
              |   0.85 |   5.82 |   6.67
              |  12.70 |  87.30 |
              |   7.21 |   6.59 |
     ---------+--------+--------+
         15   |      4 |     59 |     63
              |   0.42 |   6.24 |   6.67
              |   6.35 |  93.65 |
              |   3.60 |   7.07 |
     ---------+--------+--------+
     Total        111      834      945
                11.75    88.25   100.00
```

```
                    The FREQ Procedure

             Statistics for Table of order by S_F

   Statistic                    DF      Value      Prob
   ------------------------------------------------------
   Chi-Square                   14    32.0941    0.0039
   Likelihood Ratio Chi-Square  14    26.2569    0.0240
   Mantel-Haenszel Chi-Square    1    11.4856    0.0007
   Phi Coefficient                     0.1843
   Contingency Coefficient             0.1812
   Cramer's V                          0.1843

                  Sample Size = 945
```

```
                    The FREQ Procedure

                 Table of order by S_F

        order(order)      S_F(S_F)

        Frequency|
        Percent  |
        Row Pct  |
        Col Pct  |       0|       1|  Total
        ---------+--------+--------+
             2 |       7 |      56 |      63
               |    0.79 |    6.35 |    7.14
               |   11.11 |   88.89 |
               |    7.69 |    7.08 |
        ---------+--------+--------+
             3 |       8 |      55 |      63
               |    0.91 |    6.24 |    7.14
               |   12.70 |   87.30 |
               |    8.79 |    6.95 |
        ---------+--------+--------+
             4 |       8 |      55 |      63
               |    0.91 |    6.24 |    7.14
               |   12.70 |   87.30 |
               |    8.79 |    6.95 |
        ---------+--------+--------+
             5 |      10 |      53 |      63
               |    1.13 |    6.01 |    7.14
               |   15.87 |   84.13 |
               |   10.99 |    6.70 |
        ---------+--------+--------+
             6 |       8 |      55 |      63
               |    0.91 |    6.24 |    7.14
               |   12.70 |   87.30 |
               |    8.79 |    6.95 |
        ---------+--------+--------+
             7 |       6 |      57 |      63
               |    0.68 |    6.46 |    7.14
               |    9.52 |   90.48 |
               |    6.59 |    7.21 |
        ---------+--------+--------+
             8 |       4 |      59 |      63
               |    0.45 |    6.69 |    7.14
               |    6.35 |   93.65 |
               |    4.40 |    7.46 |
        ---------+--------+--------+
        Total         91      791      882
                   10.32    89.68   100.00
        (Continued)
```

```
                 The FREQ Procedure

              Table of order by S_F

       order(order)     S_F(S_F)

       Frequency|
       Percent  |
       Row Pct  |
       Col Pct  |        0|        1|   Total
       ---------+--------+--------+
              9 |      6 |     57 |      63
                |   0.68 |   6.46 |    7.14
                |   9.52 |  90.48 |
                |   6.59 |   7.21 |
       ---------+--------+--------+
             10 |      5 |     58 |      63
                |   0.57 |   6.58 |    7.14
                |   7.94 |  92.06 |
                |   5.49 |   7.33 |
       ---------+--------+--------+
             11 |      5 |     58 |      63
                |   0.57 |   6.58 |    7.14
                |   7.94 |  92.06 |
                |   5.49 |   7.33 |
       ---------+--------+--------+
             12 |      6 |     57 |      63
                |   0.68 |   6.46 |    7.14
                |   9.52 |  90.48 |
                |   6.59 |   7.21 |
       ---------+--------+--------+
             13 |      6 |     57 |      63
                |   0.68 |   6.46 |    7.14
                |   9.52 |  90.48 |
                |   6.59 |   7.21 |
       ---------+--------+--------+
             14 |      8 |     55 |      63
                |   0.91 |   6.24 |    7.14
                |  12.70 |  87.30 |
                |   8.79 |   6.95 |
       ---------+--------+--------+
             15 |      4 |     59 |      63
                |   0.45 |   6.69 |    7.14
                |   6.35 |  93.65 |
                |   4.40 |   7.46 |
       ---------+--------+--------+
       Total          91      791      882
                   10.32    89.68   100.00
```

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The FREQ Procedure

Statistics for Table of order by S_F

Statistic	DF	Value	Prob
Chi-Square	13	6.7760	0.9133
Likelihood Ratio Chi-Square	13	6.7859	0.9128
Mantel-Haenszel Chi-Square	1	1.9208	0.1658
Phi Coefficient		0.0877	
Contingency Coefficient		0.0873	
Cramer's V		0.0877	

Sample Size = 882

Obs	wavecat	ID	_TYPE_	_FREQ_	success
1	0	1	0	14	14
2	0	2	0	14	11
3	0	3	0	14	9
4	0	4	0	14	14
5	0	5	0	14	13
6	0	6	0	14	14
7	0	7	0	14	6
8	700	8	0	14	10
9	700	9	0	14	10
10	700	10	0	14	12
11	700	11	0	14	14
12	700	12	0	14	14
13	700	13	0	14	12
14	700	14	0	14	14
15	700	15	0	14	13
16	700	16	0	14	14
17	700	17	0	14	14
18	700	18	0	14	1
19	700	19	0	14	14
20	700	20	0	14	14
21	700	21	0	14	13
22	700	22	0	14	14
23	700	23	0	14	12
24	700	24	0	14	14
25	700	25	0	14	14
26	700	26	0	14	7
27	700	27	0	14	14
28	700	28	0	14	13
29	700	29	0	14	14
30	700	30	0	14	14
31	700	31	0	14	14
32	700	32	0	14	14
33	700	33	0	14	13
34	700	34	0	14	12
35	700	35	0	14	14
36	700	36	0	14	13
37	700	37	0	14	14
38	700	38	0	14	13
39	700	39	0	14	14

```
40      700     40      0       14       7
41      700     41      0       14      13
42      700     42      0       14       5
43      700     43      0       14      13
44      700     44      0       14       5
45      700     45      0       14      13
46      700     46      0       14      14
47      700     47      0       14      14
48      700     48      0       14      14
49      700     49      0       14      10

50      800     50      0       14      14
51      800     51      0       14      14
52      800     53      0       14      14
53      800     54      0       14      14
54      800     55      0       14      14
55      800     56      0       14      14
56      800     57      0       14      14
57      800     58      0       14      14
58      800     59      0       14      14
59      800     60      0       14      14
60      800     61      0       14      14
61      800     62      0       14      14
62      800     63      0       14      14
63      800     64      0       14      14
```

The GLM Procedure
Class Level Information

Class	Levels	Values
wavecat	3	0 700 800

Number of Observations Read   63
Number of Observations Used   63

The GLM Procedure

Dependent Variable: psuccess

Source	DF	Sum of Squares	Mean Square	F Value
Pr > F				
Model	2	2052.15420	1026.07710	2.81
0.0681				
Error	60	21904.76190	365.07937	
Corrected Total	62	23956.91610		

R-Square	Coeff Var	Root MSE	psuccess Mean
0.085660	21.30521	19.10705	89.68254

Source	DF	Type I SS	Mean Square	F Value
Pr > F				
wavecat	2	2052.154195	1026.077098	2.81
0.0681				
Source	DF	Type III SS	Mean Square	F Value
Pr > F				
wavecat	2	2052.154195	1026.077098	2.81
0.0681				

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```
                         The GLM Procedure
                       Least Squares Means
              Adjustment for Multiple Comparisons: Tukey-Kramer

                       psuccess        Standard                    LSMEAN
          wavecat        LSMEAN           Error     Pr > |t|       Number

          0            82.653061        7.221786      <.0001            1
          700          87.414966        2.948282      <.0001            2
          800         100.000000        5.106574      <.0001            3


                  Least Squares Means for effect wavecat
                   Pr > |t| for H0: LSMean(i)=LSMean(j)

                      Dependent Variable: psuccess

              i/j              1             2             3

               1                         0.8150        0.1308
               2           0.8150                      0.0915
               3           0.1308        0.0915
```

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