LIE DETECTION BASED ON HUMAN AUTONOMIC NERVOUS SYSTEM ANALYSIS THROUGH REAL-TIME EYE IMAGE STREAM

By

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DECLARATION

No portion of the work presented in this study has been submitted in support of another award or qualification either at this institute or elsewhere.

DEDICATION

We would like to dedicate this project to our loving parents for their unwavering support and to the talented, energetic faculty of our college for their guidance and assistance.

ABSTRACT

Response of the autonomic nervous system can be assessed by quantifying the dilation of the pupil of a human placed under suitable luminous conditions. When the intensity of the surrounding light is low, human's pupil dilates to capture a maximum number of photons. At the same time dilation is affected by Human Autonomic nervous System response. The aim of this paper is to assess the effects of stress on pupil through Autonomic Nervous System that an Individual experiences, with a view to apply it in a practical manner for detecting a lie during the course of interrogation. The paper presents two point algorithm devised specifically for pupil detection under Infrared rays at higher speed as compared to present day Algorithm and suggest research methodology for future.

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CHAPTER 1

1. INTRODUCTION.

1.1. Background.

Physiology is a branch of biology that deals with the physical and chemical processes involved in the functioning of the human body. Psychology is an academic discipline, a profession and a science dealing with the study of mental processes and behavior of people. Physiopsychology is the study of the way that the human mind affects the body's physical processes which include eyes. Pupilometry is the study of how a pupil reacts to different emotions and stimuli. The research on the topic of Pupilometry is scattered and fairly shallow. This project involves the understanding of Image processing based on Pupilometry, Interrogation techniques and research in the areas of Physiopsycology and Autonomic nervous system. This chapter introduces the Lie detector basing on autonomic nervous system, with image stream analysis and the development of this project. It includes both the brief and detailed objectives. The benefits of the project as well as the background are also provided. This chapter gives a brief overview of the entire document. In the field of Intelligence, interrogation is often used to gather and test the validity of information. Until the invention of the polygraph machine, the only method of lie detection available was the interrogative skills of trained interrogators or the phenomenon of third degree investigation which was unjust and cruel moreover there are many chances of errors in such an investigation .Third degree investigation is substituted by Polygraph in few of the cases. Polygraph is a set of equipment that accurately measures various sorts of bodily activity such as heart rate, blood pressure, respiration, and palmer sweating. In recent years brain activity has also begun to be measured in this setting. This bodily (and brain) activity can be displayed via ink writing pens on to charts or via a computer's visual display unit. As the polygraph machine is fairly effective, it is used by the inter-services intelligence of Pakistan along with many other intelligence agencies worldwide. In 1986 the British Psychological Society (BPS) published the report of its first working group on the use of the polygraph in criminal investigation and personnel screening [1]. Since then a considerable further amount of research has been published on the topic of first degree investigation and forensic science. The polygraph

continues to be the subject of a great deal of scientific and public controversy .The polygraph (from the Greek 'poly' = 'many', and 'graph' = 'to write') is widely used by analytical staff in a variety of medical and scientific settings for purposes other than lie detection. In lie detection situations its use is based on the premise that lying is accompanied by changes in the activity measured by the polygraph.

1.2. A Good Psychometric Procedure.

One of the major topics that psychologists and others have focused on across the decades is to determine if a testing procedure can be relied upon or not. Obviously, many issues are involved in this, but the most important ones include validity and reliability. Validity concerns the extent to which a procedure measures what it is claimed to measure, and validity can have several components.

1.2.1. Components of Validity.

Face validity refers to the extent to which a procedure 'on the face of it' appears to measure what it is claimed to measure. Content validity concerns the relationship of the contents within a test to the construct being measured. Predictive (or criterion) validity is the extent to which scores on the measure relate to or can predict outcomes. Thus, regarding a testing procedure, how accurate the procedure is at classifying people (e.g. as lying or truth telling). This typically has been the focus of our work. Construct validity is concerned with the relationship of the measure to underlying theory and constructs. This is a broad notion that includes the quality and extent of the (research) evidence that underpins such theory and concepts. Freedom from bias would generally be assessed as part of construct validity. (Criminal courts, for example, are now focusing more on this form of validity). Incremental validity is concerned with how well a procedure compares with other procedures designed to achieve the same ends (e.g. determine whether a person is being deceptive).

1.2.2. Reliability.

Reliability, within psychology, refers not to the accuracy of evaluations but to their consistency across time or among examiners. Within psychology it is often the word 'validity' that is concerned with accuracy. A number of different forms of reliability are relevant to lie detection system through pupil's image stream analysis. One main form is 'inter-examiner' reliability which concerns, for example, whether different examiners

when looking at a person's physiological activity during responses to incriminating and no incriminating questions come to the same conclusions.'Intra-examiner' reliability is concerned with the extent to which the same examiner, on different occasions, comes to the same conclusion when looking at a record of a person's physiological activity. 'Test-re-test' reliability involves the extent to which when re-tested a person's activity leads examiners to the same decision on both occasions. 'Inter-item' reliability refers to the extent, for example, that different incriminating questions lead to the same conclusion and/or that observation of the different types of bodily activity during a test lead to the same conclusion. It should be noted that a reliable procedure (in the senses described above) is not necessarily a valid procedure, for it might produce consistent but inaccurate results.

1.3. Detailed Objectives.

In the field of Intelligence, interrogation is often used to gather and test the validity of information. Polygraph is the only artificial aid in addition to interrogators skills. Trained agents/subjects can easily manipulate the polygraph result during the process. This helps in hiding facts. Response of the autonomic nervous system can be assessed by quantifying the dilation of the pupil of a human placed under suitable luminous conditions. Human Autonomic Nervous system directly effects the pupil Diameter variation Pattern. Lie deception detection is possible from Pupil dilation Patterns analysis. Dilation patterns in form of waveforms can present an index of Sympathetic and Parasympathetic reactions in real-time interrogation. Eye is sensitive to light and Autonomic nervous system response and a well designed system can isolate autonomic systems response from papillary reactions. The proposed system provides us a liar detector basing on autonomic nervous system.

CHAPTER 2

2. LITERATURE REVIEW.

2.1. Polygraph.

The use of the polygraph in criminal investigations is described first because this is the use that has been most researched Polygraph tests are currently used in criminal investigations in many countries including Belgium, Canada, Israel, Japan, Turkey, Singapore, South Korea, Mexico, Pakistan, the Philippines, Taiwan, Thailand, and the USA. A polygraph is sometimes called a lie detector, but this term is misleading. A polygraph does not detect lies, but only arousal which is assumed to accompany telling a lie. Polygraph examiners have no other option than to measure deception in such an indirect way, as a pattern of physiological activity directly related to lying does not exist.

2.2. Event-Related Brain Potentials.

Electrical activity within the brain can be detected using electrodes on the scalp. One aspect of this is usually referred to as the 'P300' component, which relates to a response occurring in the brain approximately 300 milliseconds after a 'significant' event has taken place. There is a considerable body of published literature on the general psychological significance of this response which is thought to be related to information processing .guilty knowledge test. Also, since the P300 may be small when a person is carrying out a concurrent task, reductions in it could occur when a person is having to concentrate on lying. The 2003 NRC report [2] concluded that as yet there had been published 'very limited data on accuracy' but that the use of P300 in lie detection settings could have accuracy 'level similar to that of the polygraph'. Of interest is the under-researched notion that since P300 and traditional polygraphy measure different types of activity, combining the two might result in higher accuracy. Also under-researched is the effect of the use of counter measures on P300 accuracy.

2.3. Functional Brain Imaging.

Functional brain imaging involves measuring blood activity in the brain using positron emission topography (PET) or magnetic resonance imaging (MRI). These procedures are proving useful in studying neural correlates of psychological functioning. However, using such procedures to study brain activity that may be associated with lying has only

recently commenced. One problem facing such work is that the parts of the brain that may be more active during deception also are probably more active during non-deceptive activities. Thus the false positive errors found in traditional polygraphy may occur using measures of brain activity. Functional brain imaging is currently very expensive and time-consuming. It is also probably alarming to those asked to undertake it in attempts to detect deception, including innocent people. More research is needed on the possible use of functional brain imaging to detect deception.

2.4. Behavior or Demeanor.

In contrast to the very limited amount of research published concerning the possible links between brain activity and deception, there is a wealth of published research on the possible relationships between demeanor/bodily behavior and deception. This type of research concerns lying in low stakes situations (e.g. merely for the purpose of the experiment – as is the case in many laboratory-based polygraph experiments).Much of such research has found that people are often poor at detecting lying/truth telling from others' bodily (including facial) behavior, including relevant professionals. However, a few studies have employed more ecologically valid, high stakes situations and these have found performance levels of noticeably above chance level but yet far from perfect (i.e. levels of performance not that different from those sometimes found with the polygraph). In most of these demeanor studies the observers have received no relevant training. However, the limited amount of published research on such training does not reliably find improvements in performance. One possible advantage regarding the observation of demeanor is that, unlike traditional polygraphs, it can be done non-invasively. Memon (2003) [3] reviewed the published research on criteria-based content analysis, a procedure that examines the contents of accounts for criteria expected to be more often present in truthful accounts. This procedure was developed for analysis of statements by (alleged) victims and it has rarely been applied to the statements of suspects. While some of its criteria may be relevant to this report (i.e. those believed to be associated with cognitive difficulties relating to lying) others may not be. Nevertheless, there are a growing number of research studies that have found that CBCA criteria are more present in truthful accounts than in false accounts, though which criteria actually found to discriminate varies across studies. Some other methods of language content analyses have begun to be

researched but, as yet, insufficient findings are available on the effectiveness of these procedures. The National Research Council was of the view that ‘efforts to design measures for the detection of deception based on language use may have untapped potential’ Voice stress analysis. As stated in the previously, overviews of the relevant research have concluded that some aspects of speech (e.g. changes in voice pitch) may relate, though imperfectly, to lying. However, in its review of various instruments and procedures designed to detect deception by voice stress analyses the National Research Council concluded that ‘The practical performance of voice stress analysis for detecting deception has not been impressive’ and that the relevant research offers ‘little or no scientific basis for the use of voice measurement instruments as an alternative to the polygraph’ Indeed, voice stress analysis shares many weaknesses with the polygraph (e.g. measuring stress but this may not be caused by deception). However, unlike the polygraph, voice analysis need not be invasive.

2.5. ‘Personality’ Testing.

Alternatives to the polygraph test for pre-employment screening purposes have proliferated in the wake of the USA Employee Polygraph Protection Act of 1988. Many USA companies previously engaged in polygraph-based employment screening developed alternative measures of integrity to meet their clients’ needs. This has led to the creation of many tests specifically designed to assess honesty or integrity in the workplace. The more general term ‘integrity’ testing has replaced the term ‘honesty’ testing. The aim of such tests is to screen out job applicants who are likely to engage in various forms of counterproductive behavior at work, such as theft, absenteeism, tardiness, drug abuse, sabotage or spying. At the same time there has been a renewed interest among psychologists in personality assessment generally and its use for the purpose of employee selection. Personality testing is now widely used in pre-employment screening to help match applicants to jobs and has empirical support in terms of moderate predictive validity. Related to the growth in personality testing in pre-employment screening is the improvement in measures of personality that has resulted from the emergence of a widespread (but not unanimous) consensus on the structure of personality. There is now considerable agreement on a hierarchical model of personality traits with five dimensions or factors: Extraversion, Agreeableness, Conscientiousness,

Emotional Stability, and Intellect/Openness. Valid and reliable measures of these five dimensions have been developed and used to predict various criteria, including job performance and workplace deviance. Measures of integrity for the assessment of aspects of trustworthiness at work have been derived from broader personality inventories such as by using scores on the Conscientiousness dimension of five-factor personality inventories. Both types of measures can typically be administered using paper and pencil forms, or these days via the internet, and are widely used as alternatives to the polygraph in employee screening for integrity. The range of behaviors encompassed by the integrity construct is extremely wide, and any one test is, therefore, unlikely to be a valid and reliable measure of the full range of deviant workplace behaviors. Overt integrity tests typically are designed to assess common workplace deviance, which can be seen as consisting of two broad categories of behavior organizational deviance (behaviors directed at harming the organization such as theft and absenteeism) and interpersonal deviance (behaviors directed at harming other people in the workplace such as rudeness). Overt integrity tests are composed of items that directly ask about past workplace behavior such as theft and tardiness. Their items often resemble the types of questions used in polygraph screening. In contrast, personality-based integrity testing uses measures of a personality trait such as Conscientiousness to provide a less direct way of assessing characteristics that are likely to predict workplace deviance a good psychometric procedure should demonstrate reliability and validity most published research on polygraphy deception detection has been concerned with its possible use in criminal investigations. The results of better quality research studies demonstrate that while the correct classification of deceivers can sometimes be fairly high, incorrect decisions about who is or is not being deceptive occur at rates that are far from negligible. Use of countermeasures may well result in deceivers not being detected. Use of the polygraph in employment and security screening is not justified by the available research evidence. More research is needed on other possible methods to detect deception, honesty and integrity. Over confidence in the ability of any procedure designed to detect deception can have serious consequences, especially if the deceivers are few among many non-deceivers.

2.6. Lie Detection Techniques.

Three of the four most popular lie detection procedures could be implemented using our lie detector through pupil's image stream analysis which are (Relevant/Irrelevant Test, Control Question Test and Directed Lie Test, all discussed below) are built upon the premise that, while answering so-called 'relevant' questions, liars will be more aroused than while answering so-called 'control' questions, due to a fear of detection (fear of getting caught lying). This premise is somewhat naive as truth tellers may also be more aroused when answering the relevant questions, particularly: when these relevant questions are emotion evoking questions (e.g. when an innocent man, suspected of murdering his beloved wife, is asked questions about his wife in a test, the memory of his late wife might re-awaken his strong feelings about her); and when the innocent examinee experiences fear, which may occur, for example, when the person is afraid that his or her honest answers will not be believed by the examiner. The other popular test (Guilty Knowledge Test, discussed below) is built upon the premise that guilty examinees will be more aroused concerning certain information due to different orienting reactions, that is, they will show enhanced orienting responses when recognizing crucial details of a crime. This premise has strong support in psycho physiological research. Many different tests exist, but we will restrict ourselves to briefly describing the four most popular tests.

2.6.1. The Relevant or Irrelevant Technique.

One of the oldest procedures is the Relevant/Irrelevant Technique (RIT), developed by Larson in 1932. In the RIT, two types of questions are asked, crime-relevant questions and crime irrelevant questions. Crime-relevant questions are related to the crime under investigation, such as 'Did you steal the money from the company office last night?' All examinees (i.e. employees of the company), both innocent and guilty, will answer 'no' to this question, otherwise they admit having committed the crime. Irrelevant questions have nothing to do with the crime, and the examiner knows for sure that the examinee will tell the truth while answering these questions. An example of a crime irrelevant question is 'is today Tuesday?' The examiner will then compare the physiological responses to both types of questions. The rationale behind the RIT is that larger responses to relevant crime related questions than to irrelevant questions indicate that the examinee

was lying while responding to the crime-relevant questions. However, the premise used in RIT tests is incorrect. A strong physiological response could also occur, for example, when truthful examinees are afraid of not being believed. Also, in the context of a criminal investigation, the question 'Did you steal that money?' is likely to be more arousal provoking than the question 'Is today Tuesday?' It is, therefore, clear that RIT is an inappropriate technique in testing. Larson himself acknowledged the limitations of his technique and declared that he was not particularly happy with the importance others gave to it. He said [4] 'I originally hoped that instrumental lie detection would become a legitimate part of professional police science. It is little more than a racket. The lie detector, as used in many places, is nothing more than a psychological third-degree aimed at extorting confessions as the old physical beatings were. At times I'm sorry I ever had any part in its development'.

2.6.2. The Control Question Test.

The Control Question Test (CQT, also labeled the Comparison Question Test) compares responses to relevant questions with responses to control questions. Relevant questions are specific questions about the crime. A relevant question in a murder investigation could be: 'On March 12, did you shoot Mr. Allah Ditta? Control questions deal with acts that are indirectly related to the crime under investigation, and do not refer to the crime in question. They are general in nature, deliberately vague, and cover long periods of time. They are meant to embarrass the suspects (both guilty and innocent) and to evoke arousal. This is facilitated by giving the suspect no choice but to lie when answering the control questions. Examiners formulate control questions for which, in their view, denials are deceptive. The exact formulation of these questions will depend on the examinee's circum-stances, but a control question in an examination regarding a murder might be: 'Have you ever tried to hurt someone to get revenge?' where the examiner believes that the examinee did indeed hurt someone earlier in his life. Under normal circumstances, some examinees might admit this (control) wrong-doing. However, during an instrumental lie detection examination they will not do this because the examiner will tell the examinee that admitting this would cause the examiner to conclude that the examinee is the type of person who would commit the crime in question and would, therefore, be considered guilty. Thus, the examinee has no other choice than to deny this (earlier)

wrong-doing and thus to be untruthful in answering the control questions. Obviously, an examinee cannot be found guilty for having committed the crime under investigation by answering control questions untruthfully, as the control questions are not directly related to the crime. The examiner knows this and in that respect their statements are purposefully misleading. The CQT is based on the assumption that in the innocent suspect, control questions will generate more arousal than the relevant questions. This pattern will emerge because the innocent examinee will become more concerned with regard to his or her answers to the control questions, because: (i) the examiner puts so much emphasis on the control questions; and (ii) the examinee knows he or she is lying to the control questions but is answering the relevant questions truthfully. However, the same control questions are expected to elicit less arousal in guilty suspects than the relevant questions. A guilty suspect gives deceptive responses to both types of question, which in principle should lead to similar physiological responses to both types of question. However, relevant questions represent the most immediate and serious threat to the examinee, which are expected to lead to a stronger physiological response than the control questions. Several problems have been identified with this method including the following three problems. First, although the method may be an improvement compared to the RIT, the alternative explanations for heightened arousal when answering relevant questions (i.e. (i) arousal evoking questions, and (ii) the fear of not being believed) still cannot be ruled out. Second, the examiner purposefully misleads the examinee. This misleading aspect is essential in the test, as creating arousal while answering control questions is necessary for innocent examinees to pass the test. However, misleading suspects may well be considered unethical in some countries. Guidelines on testing typically stress the importance of providing testers with clear information on assessment processes. Third, the test is not standardized, as the control questions that could be asked depend on the type of crime under investigation. When investigating a theft different control questions need to be asked than when investigating a murder. Also, control questions such as ‘Have you ever tried to hurt someone to get revenge?’ can only be asked to examinees that are known to have hurt someone in the past. The lack of standardization means that much depends on the skills of the individual examiner who formulates the questions.

2.6.3. The Directed Lie Test.

This standardization issue is addressed in the Directed Lie Test. In a DLT test, the control questions are standardized and can be asked in all situations. Typical examples of such control questions are ‘During the first 27 years of your life, did you ever tell even one lie?’ and ‘Before age 27, did you ever break even one rule or regulation?’ Examinees will be instructed to answer ‘No’ to these questions. They will also be instructed to think about particular situations in which they did tell a lie or did break a rule during these (control) denials. The rationale behind the DLT is similar to the rationale behind the CQT. Guilty suspects are thought to be mostly concerned with the relevant questions and are expected to show the strongest responses to these questions; innocent suspects are thought to be more concerned with the (control) directed lie questions since they will be concerned that their responses while lying (i.e. to directed lie questions) differ from their responses when telling the truth (i.e. to relevant questions). Although the standardization problem of the CQT might be reduced with the DLT test, the issues of relevant questions which might be more arousal-evoking than the control questions and fear of not being believed while replying to relevant questions remain.

2.6.4. The Guilty Knowledge Test

The aim of the Guilty Knowledge Test (GKT) (sometimes known as the concealed information test) is to examine whether examinees possess knowledge about a particular crime that they do not want to reveal. For example, suppose that the examinee killed somebody with a knife, left the knife at the murder scene, but now denies any involvement in the crime. In a Guilty Knowledge Test the examiner will show this suspect several types of knife, including the one used in the murder. For each knife the examinee will be asked whether he or she recognizes the knife as the one used in the murder. Both innocent and guilty examinees will deny each time that they have used such a knife. A guilty examinee, however, will probably recognize the knife he or she has used. It is assumed that this so-called guilty knowledge will produce a heightened physiological response which will be detected by the lie detector. The GKT test is theoretically more sound and is less disputed amongst scientists than the CQT test.

2.7. Anatomy

Human Eye constitutes of Sclera, Iris, Comea, and Pupil. Lens, Conjunction, Vitreous, Choroids, Optic nerve, Mecula, Retina. These are illustrated in figure 2.1

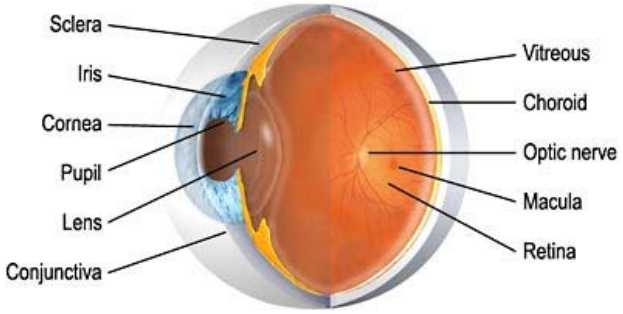

Figure.2.1. Anatomy of Eye

2.7.1. The Pupil

The iris, which is the colored part of your eye, controls the amount of light that enters the eye. The iris is a ring shaped tissue with a central opening, which is called the pupil. The pupil controls how much light enters the eye. Two muscles within the iris determine the size of the pupil. Contraction of one muscle makes the pupil larger; contraction of the other makes it smaller. Control of the size of the pupil is completely automatic. In dark conditions, the pupil dilates (gets larger) to allow more light into the eye. In bright sunlight, the pupil constricts (gets smaller) to protect the retina.

2.7.2. Dilator Papillae Muscle

The iris dilator muscle, also known as the pupil dilator muscle, papillary dilator, dilator papillae, or radial muscle of iris, is a muscle of the body. It is antagonistic to the iris sphincter muscle. It is innervated by sympathetic fibers and cause dilatation of pupil.

2.8. Pupillometry

Pupillometry is the study of the contraction/dilation of the pupil. Note this does not include tracking where the eye is looking. Changes in the size of the pupil have been linked to complex problem solving, sleepiness, and attentiveness. The sensors available range from crude gauges to an infrared camera with automated measurement software. None of them are well suited to the VR space.

2.9. Autonomic Nervous System

The autonomic nerve fibers form a subsidiary system that regulates the iris of the eye and the smooth-muscle action of the heart, blood vessels, glands, lungs, stomach, colon,

bladder, and other visceral organs not subject to willful control. Although the autonomic nervous system's impulses originate in the central nervous system, it performs the most basic human functions more or less automatically, without conscious intervention of higher brain centers. Because it is linked to those centers, however, the autonomic system is influenced by the emotions; for example, anger can increase the rate of heartbeat. All of the fibers of the autonomic nervous system are motor channels, and their impulses arise from the nerve tissue itself, so that the organs they innervate perform more or less involuntarily and do not require stimulation to function. The Autonomic nervous system is divided into two separate divisions called the Parasympathetic and Sympathetic Systems.

2.10. Response of Body Under Stress

When a person is under stress or fear this activates the fight, flight, or freeze reflex. They cause increased activity of the limbic system. This results in hypothalamus and strong emotional reactions can trigger the hypothalamus as strongly as physical pain stimuli. Epinephrine and nor epinephrine are released from the adrenal glands through stimulation by the sympathetic nervous system using nor epinephrine neurons. The sympathetic stimulation of the adrenal glands is regulated through the hypothalamus and is simultaneous with ACTH release. Epinephrine makes a heart beat faster and pumps you up so you can do extra work. Autonomic nervous system response can be characterized as Sympathetic or parasympathetic response. Fight or flight reaction = an especially strong activation of the sympathetic nervous system also called the sympathetic alarm reaction. This fact was illustrated by Dr. Julian at University Of North Carolina at Chappel hill [5] Figure 2.2 refers autonomic nervous system and figure 2.3 refers parasympathetic nervous system

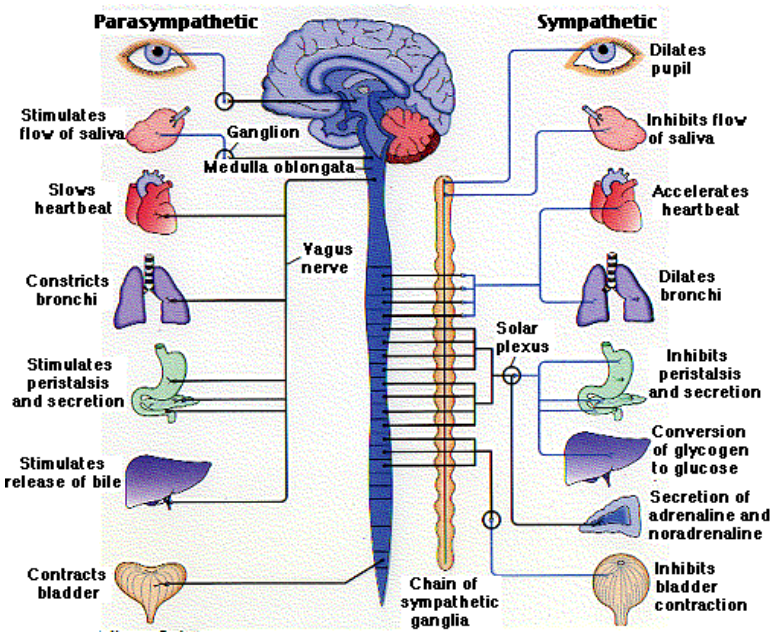

Figure 2.2 Autonomic Nervous System

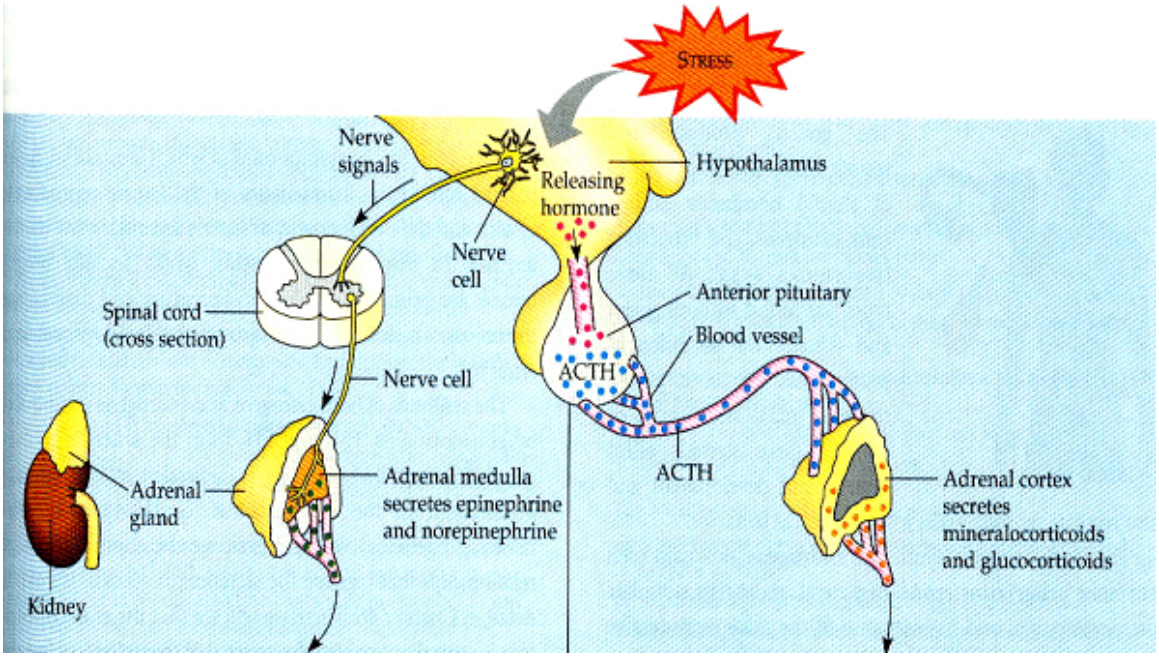

Figure 2.3 Parasympathetic Nervous System

2.11. Internal Reaction of Human Body on Occurrence of Lie

When our well being is threatened, physically or psychologically, one of our sensors, hearing, seeing, feeling or even instinct, will send alarm signals to the autonomic nervous

system which will activate its sympathetic department and take action. When the ear of the subject receives a potentially threatening message from the examiner, this stimulus is transferred via sensory neurons to the temporal lobe of the cerebrum. Regarding treating the nature of the stimulus the signal is send to the frontal lobe (the centre for judgment and reasoning) where the question is perceived and a judgment made. If the question is perceived as threatening, the alarm is sent from the frontal lobe through the hypothalamus to the sympathetic system which will then take appropriate action i.e. a sympathetic response. (Note that this whole process cannot even be calculated in microseconds, it is semi-instantaneous). The body is now programmed for "fight or flight" mode. The change in papillary reactions is an important parameter of the autonomic nervous system. By means of pupillometry, it became possible to measure both objectively and economically these reactions. A system applying isolation from light can effectively gauge autonomic responses. These responses if converted to waveform will prove to be a reliable data form for further analysis through Artificial neural networks. Persistent regular oscillations of the pupil of the eye can be induced using a slit-lamp. The period of these oscillations, pupil cycle time (PCT), is simple to measure with a hand-held stop-watch. Evidence from pharmacological testing suggests that PCT is a sensitive measure of dysfunction of the parasympathetic efferent limb of the papillary light reflex arc. This is confirmed by the finding that PCT is prolonged in a high proportion of patients with evidence of autonomic neuropathy judged by abnormalities of their cardiovascular reflexes. The method provides a simple, non-invasive way of quantifying an autonomic reflex and it may be of value in investigating patients with diseases affecting the autonomic nervous system.

2.12. Measurement of Dynamic Pupil Response.

Various approaches have appeared in the literature for measuring dynamic pupil response. These methods can be divided into two categories; (THEIRS) imaging and (OURS) scattering techniques. They all include a non-invasive method of measuring/monitoring the pupil and stimulating the eye with a pupil constricting light. Their imaging methods, camera or video, as the technique implies, rely on imaging the eye (or a portion thereof) onto a detection device. The image of the eye (or a portion thereof) would be detected on a two-dimensional detection device (or scanning one-

dimensional device). The output of the photograph or image would be processed, for example to determine the size of the pupil. John Daugman [6] in his research presented that these imaging (camera or video) techniques, suffer from alignment problems, (i.e. alignment of the subject's eye to the detection device during measurement). In addition to the alignment shortfalls noted in the literature, there has been a lack of practical detection devices for a cost effective imaging (camera or video) pupillometer. In addition, imaging (camera or video) pupillometers require complex circuitry to support the camera or video like sensor used in the application. Similar to standard video applications, imaging pupillometers typically have limitations on sensor readout rates, similar to your camera or video having a distorted picture. This limits their utility where high-sample rates are needed for the detection of alcohol, drugs, fatigue, bio-chemicals and biological agents. Typically, imaging (camera or video) pupillometers tend to be large, desktop-based systems, and costly with added hardware to support their complex imaging (camera or video) system. This type of system collects RELATIVE pupil data where creditability, reliability, and specificity are need for accurate detection results.Eye Check, unlike the other techniques mentioned above, relies on the collection of light leaving the pupil. This type of process entitles Eye Check to measure pupil diameter and it's reaction to light in real time, for ABSOLUTE pupil dynamic measurements. Which address's the problems mentioned above; cost, size, weight, complexity, reliability, specificity, and creditability.

2.13. Research – Autonomic Nervous System

Table 2.1 illustrates effects of Sympathetic and Parasympathetic Stimulation on different structures of human body.

Structure	Sympathetic Stimulation	Parasympathetic Stimulation
Iris (eye muscle)	Pupil dilation	Pupil constriction
Salivary Glands	Saliva production reduced	Saliva production increased
Oral/Nasal Mucosa	Mucus production reduced	Mucus production increased
Heart	Heart rate and force increased	Heart rate and force decreased
Lung	Bronchial muscle relaxed	Bronchial muscle contracted

Stomach	Peristalsis reduced	Gastric juice secreted; motility increased
Liver	Increased conversion of glycogen to glucose	

Table 2.1 Research – Autonomic Nervous System

2.14. Findings.

The project group research spread over 10 months under a team of Doctors headed by Dr Ismail Khutri (Head of Department , Neurology, Alshifa International, Islamabad) concluded in 2 distinctive domains discussed as under.

2.14.1. Biological.

Pupil is index of autonomic nervous system. Autonomic nervous system affects eight organs and pupil is sensitive to light that reaches fovea (Retina). In addition to inner reaction pupil dilation is effected by light, distance and color. Sympathetic reactions generate pupil dilation patterns as a consequence of fear and self defense. Lie generates fight or flight reaction consequently triggering Sympathetic response. Dilation patterns are also dependent on consensual reflexes. Pupil dilation can not be voluntarily controlled.

2.14.2. Physical And Technical.

Pupil absorbs IR rays where as rest of eye and skin reflects it. Eye diseases develop spots on retina which can generate noise pattern during Digital Image Processing. IR image eliminates need of color recognition in retina. Outer and bottom edges of an image shows different patterns. To eliminate outer effects on pupil, eyes need to have uniform amount of luminous flux. A quality image can be produced by fixed headgear. Blinking is evasive. A waveform containing pupil variation data of 30 frames / second or more is desirable for analysis.

CHAPTER 3

3. METHODOLOGY

3.1. Introduction

This chapter includes a detailed account of the proposed system and its benefits along with the functional and non functional requirements of the system. The methodology used for the development of the system is based on those techniques and procedures that may help to remove the problems and limitations faced by previous systems.

3.2. Proposed System

The proposed solution to the problems of existing system is to develop software that is capable of detecting variations in radius of human pupil and generate a waveform for further analysis. The Matlab platform has been used for the development of the project as many features have been built into this development environment to enable creation of very advanced applications for the Windows and NT platforms. Matlab environment and its set of tools allow developers to create Windows based applications with a great level of ease

3.2.1. Functional Requirements.

Functional requirements are includes specifically designed headgear with IR sensitive camera and IR lamps to be on subject's eyes, both eyes must be covered and have under uniform luminous conditions, headgear to be connected to PC through TV tuner input card. MATLAB 2006b or above with Image acquisition toolbox 2.0 or above should be present. VCAPG2.DLL to be present in code directory., system configurations must meet ideal requirements for MATLAB 2006b.

3.2.2. Non Functional Requirements

The system was originally targeted to perform according to these non functional constraints. The generated system accepts frames at a rate of 30 FPS (Frames per Second). This is to present a smooth live view of the real environment to the user. The System should receive frames synchronously from the camera at a frame rate of 30 FPS.

Transmission of images between the modules should be in sequence and within acceptable information loss (image should be clear enough for radius calculation and wave generation). The decisions taken regarding the design and development of the system are elaborated below.

3.3. Challenges of Noise in Eye Due to Diseases

The first thing to keep in mind is that the computer can't see objects. It takes in video information as a grid of pixels. It can tell you a pixel's position and its color (if you are using a color camera). From these facts, other information can be determined; the brightest pixel can be determined by seeing which pixel has the highest color values, a "blob" of color can be determined by choosing a starting color, setting a range of variation, and checking the neighboring pixels of a selected pixel to see if they are in the range of variation, areas of change can be determined by comparing one frame of video with a previous frame, and seeing which pixels have the most significantly different color values, and areas of pattern can be followed by selecting an area to track, and continuing to search for areas that match the pattern of pixels selected.

3.4. Benefits of Proposed System

The benefit of this project lies in many spheres, the first being the relatively less expense. It provides a fool proof way to detect occurrence of a lie during the course of interrogation. It provides an efficient tool to compare waveforms generated by Polygraph. The 2 point algorithm can compute at the rate of 90 fps at 320 X 240 resolutions.

CHAPTER 4

4. Two Point Algorithm

4.1. Existing Algorithms

There are a number of algorithms available for edge detection. They vary in complexity and reciprocally provide a specific degree of accuracy. A description and working of existing Algorithms is as under.

4.1.1. Laplacian of Gaussian

The Laplacian of Gaussian method finds edges by looking for zero crossings after filtering I with a Laplacian of Gaussian filter.

4.1.2. Prewitt method

The Prewitt method finds edges using the Prewitt approximation to the derivative. It returns edges at those points where the gradient of Image is maximum.

4.1.3. Roberts method

The Roberts method finds edges using the Roberts approximation to the derivative. It returns edges at those points where the gradient of Image is
maximum.

4.1.4. Canny method

The Canny method finds edges by looking for local maxima of the gradient of I.The gradient is calculated using the derivative of a Gaussian filter. The method uses two thresholds, to detect strong and weak edges, and includes the weak edges in the output only if they are connected to strong edges. This method is therefore less likely than the others to be fooled by noise, and more likely to detect true weak edges.

4.2. Two Point Algorithm

The method gets a Grayscale image from and searches for minimum value f a pixel(Darkest Pixel). It introduces a threshold and searches for pupil in this given rage that is sum of threshold and maximum pixel value. After detecting first such pixel it check it viability of be an edge of pupil by matching it with noise pattern specified. If noise is detected it bypasses it and in the same manner reach to pupil. Finds left and bottom edge points. Compare and calculate radius of the pupil.

4.3. Results of Two Point Algorithm Comparison

After experimentation on about 50 images of 2 different resolution results are calculated. Images vary in description and detail and have a reasonable amount of error introduce. All four algorithms are tested under the same set of images. Figure 4.1 displays a comparison of algorithms on different image dimensions.

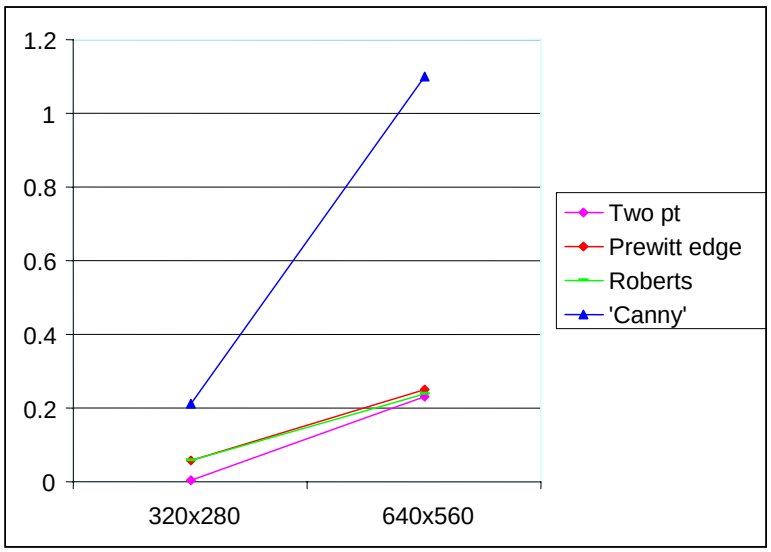

Figure 4.1 Average Result of Different Edge Detection Algorithms Comparison

CHAPTER 5

5. SYSTEM MODEL

5.1. Introduction

The proposed system is a five-stage process which is shown in block diagram of figure 1. The first stage is to acquire the image from the camera that is mounted on headgear. Once the image is acquired it is processed further. Each of these modules is discussed in detail.

5.2. Different modules of The Proposed System.

5.2.1. Video Input

The process is the basic requirement of the software getting the streaming video from the video capturing device to user view . Input required is Video Stream. The process gets the stream of video from the video capturing device and renders to the output stream. The video input is acquired from a high speed camera that is mounted on a headgear. If a video capturing device receives a stream the stream is fetched and rendered. The rendered video frames are the output of this process.

5.2.2. Image Acquisition

The Block includes the capturing of the rendered frames for processing, it allows the user to start, stop and preview the video image. The input required is rendered Video Frames. The image sequences are being acquired from a camera however the camera is mounted on a Headgear. Acquired real video images which can be further processed.

5.2.3. Waveform Generation.

Next stage is a process to generate a waveform basing on the variation in radius of pupil. Pupil Radiuses in an array are input. Algorithm detects variation in radius and generates a graphical pattern. waveform ready for analysis.

5.2.4. Database (Proposed)

Based on the analysis respective lies and truthful replies are written down in a database for future reference. This process could include the Add, Update and Delete operations on the Database.

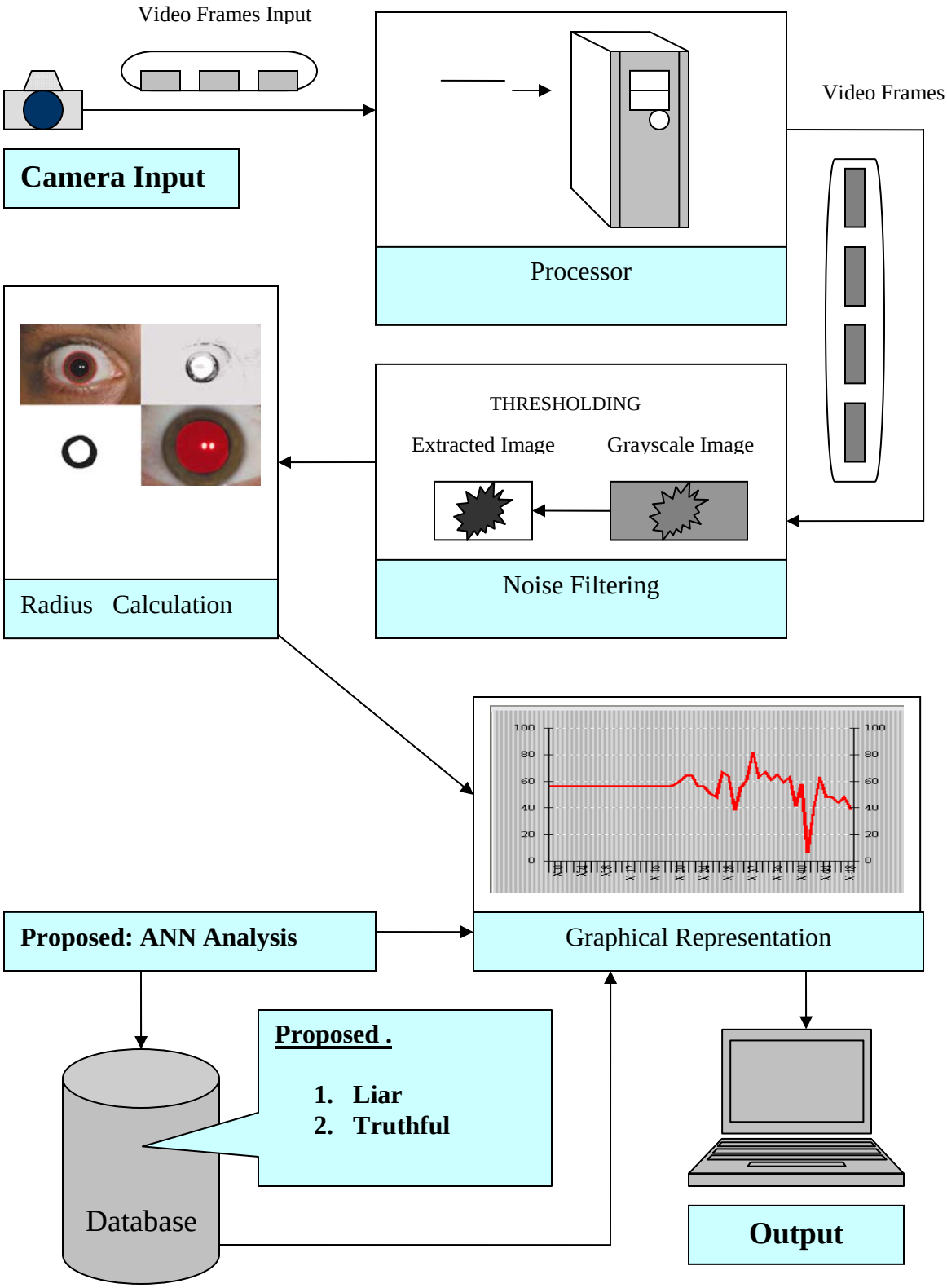

Figure 5.1 System Detailed Block Diagram

5.3. Software System Attributes

Software System Attributes discusses about the reliability, availability and maintainability of the system.

5.3.1. Reliability

The system must be able to provide all the basic functionality to the user without any delays. All the information must be available at the right time, when it is needed. System must take care of selecting the default devices.

5.3.2. Availability

Proposed system must be able to render the video from any of the capturing devices and should be able to accept and enumerate any new installed device.

5.3.3. Maintainability

Since the system can merge new devices into itself, so it is easier to maintain the system. There is also a proper communication interface defined for each device, so entry of a new device will not create any problems and system will upgrade itself.

5.3.4. Usability

System will fulfill all functional and non-functional requirements in efficient manner.

5.3.5. Affordability

The system will be economical so that it may be easily affordable and must provide all its services.

CHAPTER 6

6. DESIGN

6.1. Introduction

This chapter discusses the design process of the software. Design is the process of building a model or representation of an entity that will be built, the design expands what was learned during analysis phase into a working implementation. Design is a series of decisions on which implementation of the software is carried out. This chapter discusses the four major area of concern for the system that is the data, architecture, interfaces, and components.

6.2. Software Design

Software design is formulized using the Object Oriented Design methodology. The main components of this are ,Use Case Diagram, Data Flow Diagram ,Activity Diagram, Class Diagram.

6.2.1. Data Design

The data design transforms the information domain into the data structures that will be required to implement the software. The data objects and relationships defined in the entity relationship diagram and the detailed use case diagrams provide the basis for the data design activity.

A use case diagram illustrates a set of use cases for the software, the actors, and the relation between the actors and use cases. The purpose of this diagram is to represent a kind of context diagram by which one can quickly understand the external actors of software and the key ways in which they use it. The following are the software use-case diagram components which are actors, use cases and the relationship between them.

6.2.1.1. Actors

An actor is an entity who in some way participates in the story of use case. The actors involved in the proposed system are **User / Evaluator**: User is a person who is using the software. **PC**: Personal computer that is used to run the software. **Camera**: It's the camera that is mounted on the headgear previewing video. **Database**: The database holds the records of interreges.

6.2.1.2. Use-Cases

A use-case describes a process. A use-case is the action performed by actors.

Uses cases involved in the system are Receive the video frames. Preview the video. Preview the grey scale images. Preview the graphical representation/waveform. Manage and update the database.

Figure 6.1, 6.2 shows the UML icon for a use case actor and a use case.

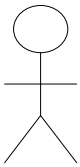

Figure 6.1 Actor icon in UML

Figure 6.2 Use case icon in UML

6.2.1.2.1. Use-case Diagram

The following is the software use-case diagram, which shows actors, use cases and the relationships between them.

6.2.1.2.2. Use-cases Description

Use case description is given in table 6.1

UC-01: **Receive the video Frames**	
Actors	Camera, PC
Assumptions	No assumptions for this use case.
Pre-conditions	Video Type signal
Use Case Description	The capture device(camera) sends the video to PC
Use Case Initialization	This use case starts on demand.
Use Case Termination	This use case terminates when interrogation is over.
Post-conditions	Upon successful the system will start analyzing the video information
UC-02: **Preview the video**	
Actors	User, PC
Assumptions	No assumptions for this use case.
Pre-conditions	Video Type signal

Use Case Description	The software takes the video from video capturing device as a camera and previews it.
Use Case Initialization	This use case starts when interrogation begins.
Use Case Termination	This use case terminates when interrogation stops.
Post-conditions	Upon successful the system will start previewing the video
UC-03: **Add, Update, Delete Records**	
Actors	User, PC, Database
Assumptions	A video is being rendered, evaluation performed
Pre-conditions	The video stream is being rendered.
Use Case Description	If the user wants database management the specific interogee's record is managed by the software.
Use Case Initialization	This use case starts when user selects database management.
Use Case Termination	This use case terminates when user exists database.
Post-conditions	Upon successful the database will reflect the updates made to it.

Table 6.1 Use-cases Description

6.2.2. Architectural Design

The architectural design represents the structure of data and the program components that are required to build a computer-based system. It considers the architectural style that the system will follow and defines the relationship between major structural elements of the software that can be used to achieve the requirements that have been defined for the system. The activity diagram shows the dynamic behavior of the system and the relationships between system modules.

6.2.2.1. Activity Diagram

Activity diagram is an activity oriented diagram. An activity is a task that needs to be done by a human or by a computer. From a specification perspective or an implementation perspective, an activity is a method for a class. It represents a series of activities that need to be completed to do a particular function. It shows behavior with

control structure, also shows many objects in single use case and implementation of methods.

Figure shows the UML icons for an activity diagram. Activity diagram for the Image Acquiring phase is shown in figure 6.3.

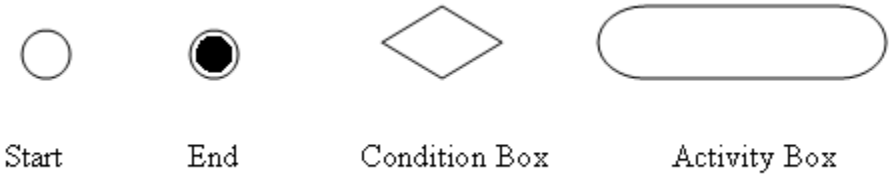

Figure 6.3 UML icons for Activity Diagram

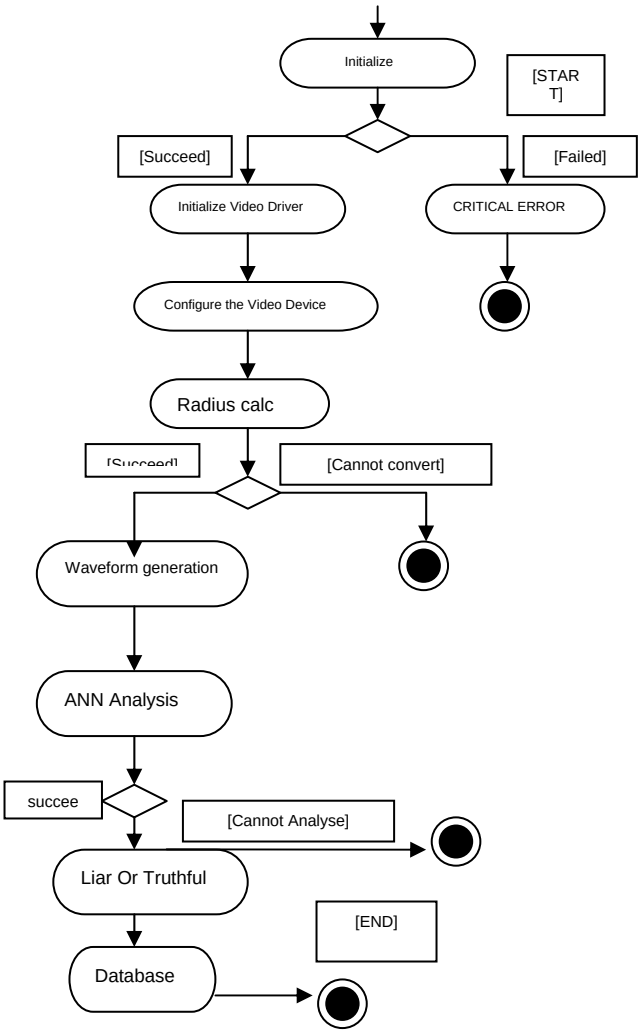

Figure 6.4 Activity diagram

6.2.3. Interface Design

The interface design describes how the software communicates within itself, with systems that interoperate with it, and with humans who use it. An interface implies a flow of information and a specific type of behavior. Therefore data and control flow diagrams provide much of the information required for interface design. The DFD provides an indication of how data are transformed as they move through the system and depict the functions that transform the data flow.

Figure 6.7 UML notations for Interface Description for DFD

6.2.4. Data Flow Model

The data flow diagram model gives details such as the primary data objects to be processed by the system, the composition of each data object and the attributes that describe this object, the relationships between each object.

The UML notations for the Data Flow Diagram are shown below. Nodes are the data objects and the links are the transformations that occur to translate one data object into another.

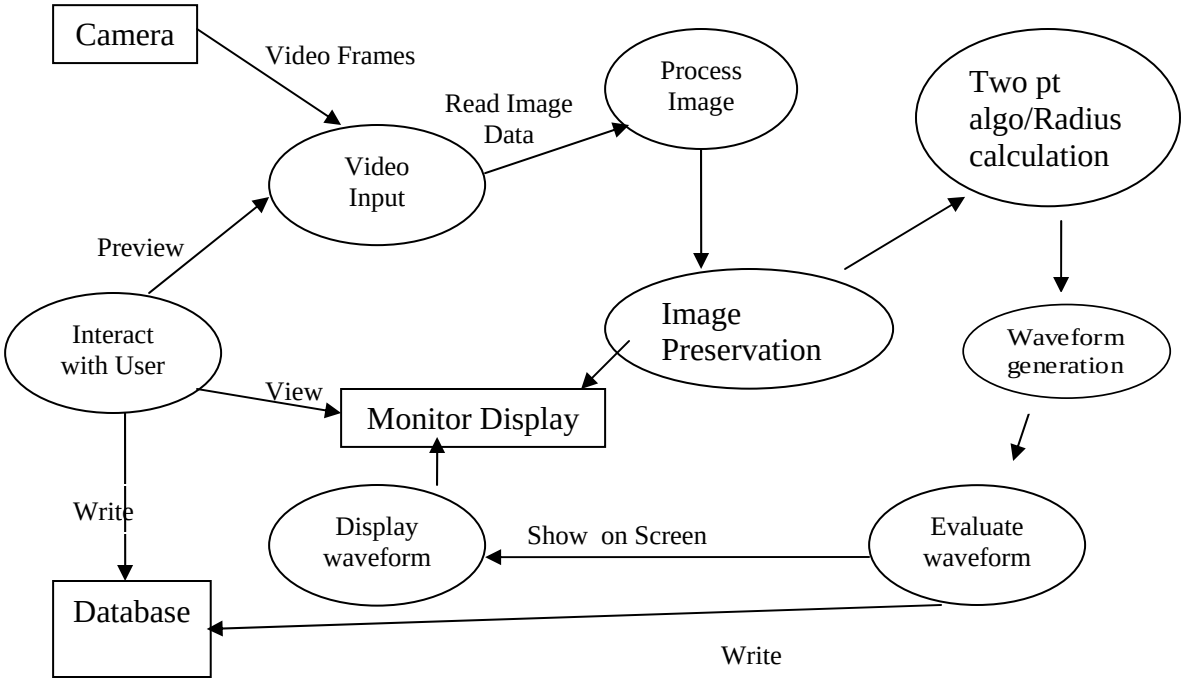

Figure 6.8 Data Flow Diagram

6.2.5. Component level Design

The Component level design transforms structural elements of the software architecture into a procedural description of software components. Class diagrams are used to show the most basic design of the software.

6.2.6. Class Diagrams

Class diagram represents some main classes and there relationships. A class diagram illustrates the specification for software classes and interfaces. Typical information it includes, Classes., Attributes ,Methods, Associations.

CHAPTER 7

7. IMPLEMENTATION

7.1.Introduction

Implementation is the next level of the design process. The Classes and code developed for the implementation of each system module will be discussed in this chapter. As mentioned in chapter 4 has 4 Modules in proposed system.

7.2.Camera Calibration

Camera selection and calibration is of great importance as image stream capturing and manipulation of the image stream are the main components of the software. The selection of a high resolution camera is a very sensitive issue. The software has to grab the image, convert it into a grayscale image and then process the data available in this grayscale image to calculate the radius of the pupil. Better the resolution of the camera good will be the picture of the pupil and easier would be for the software to calculate radius and generate waveform. For the project a camera with high resolution at least with a frame rate of 30 frames per second is required. Once the image is acquired and converted into grayscale then the software calculates the pupil radius and generates a waveform for further analysis..

7.3.Image Acquisition

Camera which is used to acquire images is taking thirty frames per second which is compatible with the software tool used.

7.4. Noise Filtering

After acquiring video frames, they are converted into grayscale images. The grayscale images include all shades of gray from black to white and it is obtained by MATLAB.

7.5.Thresh-Holding

Thresh-holding is the basis for any image processing technique. It is the fundamental concept in image extraction and to differentiate required objects to a great deal from their environment. This technique though usually very simple and easy to implement fails in situations where the back ground is cluttered. Thresh-holding is basically a process in which usually the average color over a set of pixels is determined and compared with already selected thresholds. Threshold works by setting specific values to pixels that fall within a certain range called the threshold interval. All other pixel values in the image

that do not fall in the threshold interval are set to 0. This helps to extract the object of desired intensity of color from the actual background. Thresh-holding always plays an important role in improving the efficiency of the system.Threshold is applied to the grayscale images to obtain binary images as it is fast and easy to work with binary images. A threshold operation chooses one of the pixels as the foreground pixels that make up the object of interest and sets the rest as a background.

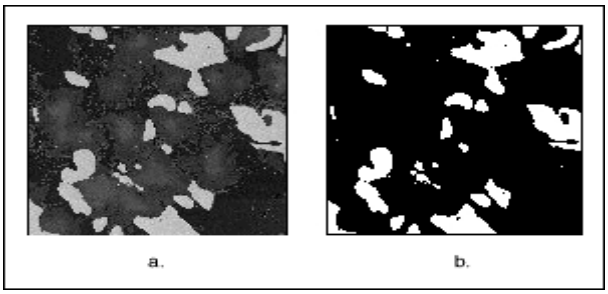

Figure 7.1 An Image Before and After Threshold

CHAPTER 8

8. TESTING

8.1.Introduction

This chapter discusses the how testing is performed on this system. Different testing techniques are applied to find the reliability of the software.Initial testing was carried out by a simple JPG image with a circle in center in RGB.Second test case was an image acquired by an IR camera in BMP. Such 1000 Images were tested and an accuracy of 93% was found. Third test case was Grayscale image stream through camera at 320 X 480 resolutions.

8.2.Limitations of the system

Needs constraint environment for getting image in real time stream. Efficiency of Algorithm is bound by hardware speed constraint. Requires distortion free image. Image to be taken under IR light. Headgear to be mounted on subjects' eyes. External effects creating distortion effects result quality.

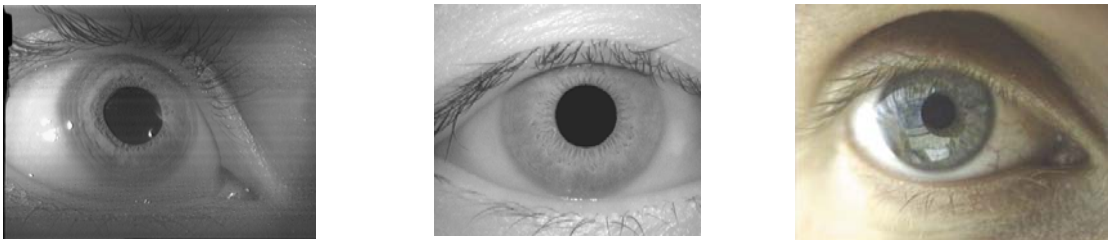

Figure 8.1 Different Test Cases Used In RGB and Grayscale

CHAPTER 9

9. FUTURE WORK AND CONCLUSION

9.1.Overview.

The system provides an effective way to generate pupil variation waveforms at higher rate as compare to existing Algorithms. The system is ready to enter in Artificial neural networks phase.

9.2.Future Work.

It is proposed that system may be used by agencies involved in interrogation. It is also suggested to incorporate forensic laboratory facilities to enhance the efficiency.

9.3.Conclusion

A very practical, efficient, foolproof and widely applicable project is presented with a huge potential of extending. According to which the change in pupillary reactions is an important parameter of the autonomic nervous system. By means of pupillometry, it became possible to measure both objectively and economically these reactions. A system applying isolation from light can effectively gauge autonomic responses. These responses if converted to waveform will prove to be a reliable data form for further analysis through Artificial neural networks.

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