FACIAL EXPRESSION RECOGNITION INTELLIGENT SECURITY SYSTEM FOR REAL TIME SURVEILLANCE

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Abstract: *Facial Expression Recognition is a part of biometric authentication that focuses on uniquely recognizing human facial appearance based upon one or more intrinsic physical or behavioral traits and inside emotions portrayed on one's face. This paper explains on research based on improving current surveillance systems by adding facial expression recognition to make a system that will detect a person's expression (who has intentions of causing harm) and report to the securities before the person can commit any prohibited work. The system captures ones feeling/expressions through a camera and send the footage for preprocessing before it can be extracted to see if the emotion/expression captured has the intentions of causing harm.*

Keywords: Facial Expression Recognition, Motion Detection, Computer Vision and Surveillance.

1 INTRODUCTION

Facial expression is regarded as way of communicating the emotional state of the individual to observers and humans can adopt a facial expression to help read as a voluntary action. The six basic facial expressions are: Joy, Surprise, Fear, Anger, Disgust and Sadness. The technology of facial expression is increasingly gaining attention of most researchers. A couple of systems have been developed based on facial expression, this includes among others: advanced human-computer interfaces, improved relations with the e-commerce consumers, and intelligent system for autistic children.

On the other hand Biometrics is seen as a way of recognizing an individual's distinctive physical or behavioral characteristics to distinguish or verify their identity. The common physical biometrics are fingerprints, hand or palm geometry, retina, iris, and facial characteristics. Many years ago biometric technologies have been used for entry access in secure environments and nowadays the primary application of biometrics is in physical security: to control access to secure locations (rooms or buildings). Biometric devices, typically hand geometry readers, are in office buildings, hospitals, casinos, health clubs and lodges. Biometrics is useful for high-volume access control.

Facial expression recognition and biometrics can play a major role in preventing many criminal activities from happening. This project is aimed at combining both facial expression and biometrics technologies to designing an intelligent surveillance system that will be able to recognize and identify any person if they have any intentions of doing any criminal activities.

2 ANALYSIS

Facial expressions from ages have been linked with people's feelings. Lie to me, a television series that goes by the motto of "Words lie but your face doesn't", also emphasis that facial expression correlates with peoples feeling. Reading human facial expressions can help us in our day-to-day activities such as in security issues, gaming technology, marketing and advertising and expert system. From the observations and study we made, we have realized that most surveillance facial recognition systems only automatically check every person against a database of known suspects. This makes it hard for securities to catch someone who has the intentions of stealing or about to do any forbidden act. Available surveillance face recognition systems are only designed for blacklist searches in criminal investigation, for the control and enforcement of bans in areas such as airports, stations, as well as casinos and sport arenas. The systems do not detect the expression of the people in the area thus giving them an allowance to commit crimes.

Figure 1 shows an example of an existing surveillance face recognition system that checks every person against a database of known suspects.

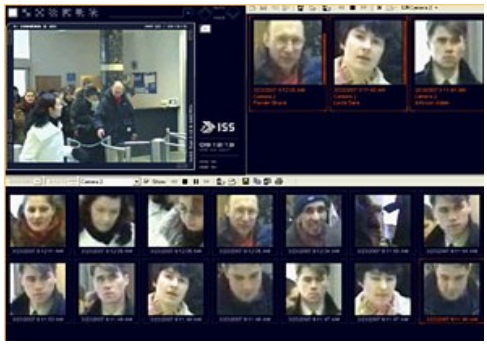

Figure 1: Example of facial recognition System

With these observations and research we see the need to research and develop a real time facial expression recognition system that will help read human facial expressions of people who their expressions show that they can cause harm or they are about to commit prohibited work and instantly alerting the guards through an alarm if the any threat has been detected.

3 RELATED WORK

3.1. Facial Recognition

Most researches stated that in order to detect a face there are some factors that must be considered to get more accurate result. These factors may in include the clothes a suspect is wearing, background color and skin illumination. (Peng, Zhu, Zhou, 2010) in their research stated that they used an adaptive Gamma Corrective method in order to get rid of influence of illumination on the skin color therefore making it easy to detect the face according to the structure of eye, nose and mouth. [1]. (Patil, Ginpunje, Bajaj, 2010) in their researched on facial expression recognition and head tracking in video using Gabor filter they pointed out that facial expression turn to become the key technology of advanced human computer as much as there is a rapid development of computer vision and artificial intelligence. In this study they proposed to use a method of detecting 28 facial key-points in images as a way of increasing the accuracy and robustness. They used Gabor filters because of its superior capability of multi-scale representation. In their process of facial expression recognition they used Gaussian filter in order to reduce some common types of noises in an image. They also applied the use of Gabor filters in the extraction process because it is used to define edges and it is the fastest method for training moderate-sized feed forward neural networks, the Levenberg-Marquardt algorithm was applied in training. [2]. In other researches (Zhao, Huang, Dellandre´a, Che, 2010) proposed automatic 3d facial expression recognition based on a Bayesian belief net and a statistical facial feature model. Bayesian Belief Network is used for 3D facial expression recognition in 3D environment because it has a novel structure that allows adding new feature and new expression flexibly. Also proposed was a novel method to compute parameters in BBN for inference belief of expression states based on the SFAM. The two (BBN with SFAM) were combined for the system to be capable of recognizing facial expression in 3D automatically and efficiently (Figure 2). [3]

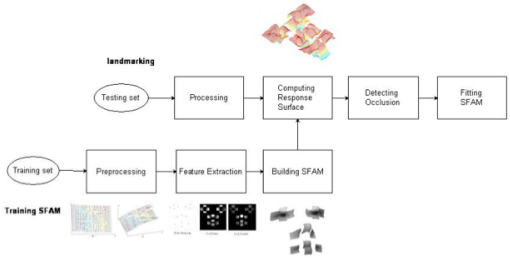

Figure 2: Flowchart for automatic land marking using SFAM

(Matai, Irturk, Kastner, 2011) presented the design and implementation of an FPGA-based real-time face recognition system (Figure 3). The system consists of 3 subsystems, which are face detection, face recognition that uses the Eigen face algorithm and down sampling. The complete system uses a camera to send the video data to the face detection subsystem, which in turn sends detected faces to the face recognition subsystem through the down sampling module that prepare images, it resize the image using the coordinates for input to face recognition. The design and implement of a face recognition subsystem on an FPGA uses both pipelined and non-pipelined architectures. FPGA Implementation of the face recognition subsystem is performed in two steps: generates the training data and the face recognition. The training data is generated using the OpenCV library and evaluate the feasibility of the face recognition subsystem using the ORL database. Face Recognition: stores the average image, the weight vectors for each image and the Eigenvectors in a block RAM. [4]

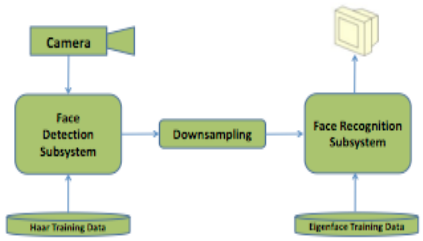

Figure 3: Flow of the FPGA-based real time face recognition system.

(Li, Phung, Bouzerdom, Tivive, 2010), proposed automatic recognition of smiling and neutral facial expression. The system has two major functionalities which are; face detection and alignment, and classification of smiling and neutral. In face detection and alignment method, the candidate eye regions are detected, based on the elongated shape of the eye and the circular shape the pupil. We will use a Gabor filter, the product of a harmonic function and a Gaussian function and a circular filter. In classification of smiling and neutral, the smiling and neutral facial expressions are differentiated using a new neural architecture, which consists of three processing stages. The three processing stage are Directional Filters; is designed to extract features at different orientations, Trainable Filters; aims to detect more complex features for classification and Classification; for classification, may use any type of classifiers. [5]

3.2. Computer Vision

(Miller G, Fels S, Oldridge S, 2011) they researched a conceptual structure for computer vision. They discuss scope of computer vision analysis and discuss a new categorization of the computer vision problem. The central theme of their contributions is to see computer vision becoming more accessible to researchers and developers alike. They use the axioms of vision as an

abstraction that builds on top of algorithmic approaches such as OpenCV to leverage the specialized knowledge contained in their impressive array of algorithms. In their axioms of vision, there are mathematical axioms, source axioms, model axioms and construct axioms. For their algorithms and problems, they discuss on how to use the axioms above using algorithm composition, problem decomposition and formal description model. They have presented the idea of an interpreter, which would take the formal description and translate it such that the correct algorithm for the problem may be chosen. [6]

(Ohsaki H, Nozaki K, Baba K, Sakane E, Sakamoto N, Koyamada K, Shimojo S, 2011) they discussed Peta-Flow Computing: Vision and Challenges. In the ICT, Peta-flow computing integrates the principal computing, networking, and interfacing technologies. It has got short, mid and long-term goals. To enable large-scale computing for geographically dispersed large volume data, Peta-scale computing is used. To enable transparent access to geographically disperse large-volume data Peta-scale networking is used and Peta-scale interfacing is a set of technologies for enabling input/output of geographically dispersed large-volume data from/to users. In all these technologies, it is noted that integrated high-speed networking with computing and interfacing technologies is necessary. At last it is important to note that high-performance computing such as large-scale computations/simulations have been leading applications of information and communication technologies, thus it is expected to continue in the peta-scale era. [8]

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3.3. Motion Detection

(Rao I, Murphy P, Nandy S, Rao V, 2009) they analyzed a real world system for detection and tracking. Their analysis comes as a necessity of inventing an intelligent surveillance system, which will make lives easier as well as enable competition with tomorrow's technology. Background subtraction is the method applied. They used pixel based approach so as to compare the corresponding pixel values of the foreground with reference to standard background. Their algorithm is implemented using image processing in MatLAB Environment of which they can achieve motion detection. They up an alarm or alert system, which is controlled by a Microcontroller (AT89C51) which is interfaced with the personal computer system through a serial communication path initiated by the MatLAB code written and executed in the personal computer. By successfully interfacing the hardware and Personal Computer system with each other by serial communication, using RS232 protocol, the microcontroller-based hardware detects the data from the system and gives the desired output. [9]. (Xiaoping LI, Tao LI, Feng LING, Jianqiang XU, 2010) Studied the technology of motion detection and target contour extraction in the intelligent analysis of video. They gets gradient contour information according to operator Canny using double threshold values method based on statistic to divide moving target. Algorithms of Motion Detection discussed in this study are; 1) Frame Difference Method: it has nothing to do with the time varying. The movement of objects cannot be described with a still picture. But this algorithm cannot extract all the moving features of targets. 2) Background Subtraction Method: a method that realizes motion detection through the subtraction of image set and referenced background model, providing holistic data of features and extract relatively holistic moving target. 3) Moving Target Detection: uses the difference between varying image and relevant background image to detect moving objects for the current image. They extracted the contour lines of Snake Model Base on Cubic B-spline. The contour line of traditional Snake model is a polygon composing of some control points. B-spline curve is located in the polygon. [10]. (Chen Y K, Cheng T Y, Chiu S T, 2009) evaluated the Entropy algorithm of moving average of objects, an alarm system with dynamic threshold. Multi-periods background estimation algorithm is applied in the proposed algorithm to derive the subtraction video. Entropy: An $M \times N$ resolution digital image of frame f may be defined as a two-dimensional function where x and y are spatial coordinates, and the amplitude of If at any pair of coordinates (x, y) is the gray level of the image at that point. The proposed algorithm is using the Manzanera's multi-periods Σ–Δ background estimation algorithm to derive the background video $Mf(x, y)$ from the input video. A single threshold is used to determine if the alarm is not suitable for the Entropy-Δ curve of the proposed algorithm. [11]

3.4. Surveillance

(Bhaumik G, Mallick T, Chowdhury K S, Dr. Sanyal G 2010) has done a research on analysis and detection of human faces by using minimum distance classifier for surveillance. This visual surveillance system in dynamic scenes that make an effort to detect, recognize and track certain object from image sequences and more generally to understand the human or object behaviour by identifying distinctive face features like the eyes, nose, mouth, and head outline, and defining a face model by the position, size, and relationships among these features. The analysis of the face is done using mathematical analysis which is has two phases, namely:

1) Calculating Eigen faces using Principle Component Analysis (PCA)

2) Face Image Classification. The type of algorithm used

is the computer algorithm [12]

(Lianyang Ma, Zhijing Liu, 2008) researched about human motion recognition in video for surveillance systems (Figure 4). This system automatically detects the moving human (walking) using a camera and following these steps motion detection, objects tracking, and behavior understanding and human identification. (See the framework of detecting human behavior in figure)This is a spatio-temporal motion-based model and offers these two contributions:

1. Inferring and generalizing from just walker silhouette (about validity of much larger context of image patterns and behavior)
2. Using Hidden Markov Models to build human posture detection model and recognize the human motion.

The method used to determine the motion of a moving bogy is the contour model that goes through the Centroid, Expression of Motive Human beings' Image Sequence, Similarity Compare and standard deviation stages. Hidden Markov Models (HMM) defines a limited state set, and each state associates with a probability distribution (multi-dimension in general). The result of the test has shown a very low recognition rate in the matching method. [13]

(Zhen Lei, Chao Wang, Qinghai Wang, Yanyan Huang 2009) researched on real-time face detection and recognition for video surveillance applications with the aim of integrating and optimization of an automatic face detection and recognition system for video surveillance applications. The work is divided into two phases, the face detection stage and face recognition stage. Under the face detection stage they looked at the extended haar-like features to trains the strong classifier that form the cascaded multilayer ear detector and the modest AdaBoost algorithm that generates a sequentially weighted set of weak base classifiers that are combined to form an overall strong classifier. In the face recognition stage, PC-ICA and hansdorff distance methods were reviewed. The PC-ICA is the method that first focuses on reducing the dimension of the data using principal component analysis (PCA), then adopt a ratio-factor-based ICA for face recognition. Hansdorff distance calculates the minimum distance between the test image and image to be recognized in the database. Tests were run in CMU+MIT frontal and the method has achieved a better detection rate in CMU+MIT as compared to other methods. [14]

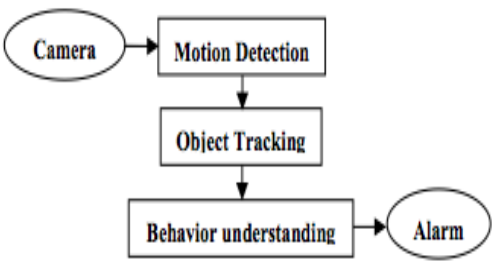

Figure 4: The framework of detecting human behavior

(Ting Shan, Shaokang Chen, Conrad Sanderson, Brian C. Lovell, 2007) examined automatic person recognition for intelligent-cctv based surveillance using one gallery image. The system uses the pose compensation technique to synthesize realistic frontal face images from non-frontal views. It is based on Active Shape Models (ASMs) and Active Appearance Models (AAMs) which are deformable models popularized by Cootes et al.. it also uses pose estimation correlation models. Adaptive Principal Component Analysis (APCA) is another technique that is used in the system to get features/characteristics from both PCA and Fisher Linear Discriminant by warping the face subspace according to the within and between class covariance. [15]

(Lin F, Fookes C, Chandran V, Sridharan S, 2006) they investigated the role of motion models in super-resolving surveillance video for face recognition. The main aim of their paper was mainly to find out the way in which motion models of different super-resolution reconstruction algorithms affect reconstruction error and face recognition rates in a surveillance environment. They applied Super-resolution image reconstruction model whereby they combine multiple low-resolution (LR) images into one image with higher resolution (Figure 5). A XM2VTS database was used facilitate testing of multi-modal speech recognition systems. After carrying out an experiment, they discovered that super resolution would only be successful if peak signal-to-noise ratio (PSNR) and structural similarity index (SSIM) were indicative of recognition performance and if there is accurate registration. They aimed at investigating quantitative measures of image quality that will give an indication of face recognition performance and do experiments on real surveillance footage as their future work. [16]

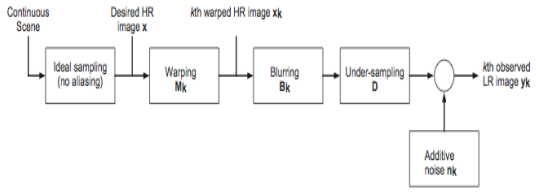

Figure 5: Super-resolution observation model

4 RESEARCH METHODOLOGY

Different projects require different methodologies to be developed. Methodology refers to the framework that is used to structure, plan, and control the process of developing a system [18]. This research follows steps that will help at the end of the research to have a clear understanding of the work and problems. These steps are:

- Understanding the nature of problem to be studied and identifying the related area of knowledge.
- Reviewing literature to understand how others have approached or dealt with the problem.
- Collecting data in an organized and controlled manner so as to arrive at valid decisions.
- Analyzing data appropriate to the problem.
- Drawing conclusions and making generalizations [17]

4.1. Objectives of Research

The research methodology is discussed in two parts: objectives of research and development methodology. The aim of the research is to:

i. To study surveillance systems and Face expression recognition, and how to combine both technologies to improve face expression recognition (in terms of motion).
ii. To develop an application for Facial Expression Recognition for surveillance systems.
iii. To evaluate real time facial expression recognition for intelligent surveillance systems.

4.2. Development Methodology

Development methodology to be used in this research is waterfall Software Development Life Cycle (WF-SDLC). Since this is a security system that combines surveillance system and facial expression technologies to come up with a real-time intelligent surveillance security system we have seen the need to add collaborative methodology to the WF-SDLC because it isn't enough for the WF-SDLC to work alone in a collaborative system. Therefore the system will be designed following the Collaborative Waterfall Software Development Life Cycle (C-WF-SDLC) (Figure 6). This system is developed in a way that it will be able to detect the person's facial expression helping the guards to foresee if the person can cause harm to other people or he has any bad intentions of committing prohibited work. The C-WF-SDLC methodology follows six main phases, that is: Planning, Analysis, Design, Implementation and Maintenance.

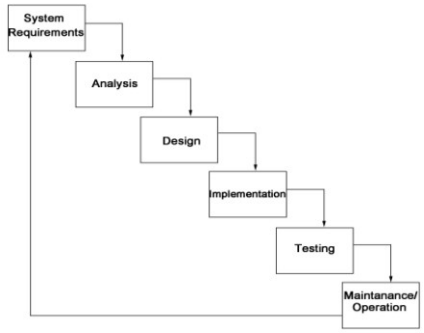

Figure 6: C-WF-SDLC

4.3. System Requirements Phase

The purpose of this phase is to determine project's main goal and how the system will function. To gather system requirements information, these are common questions that have to be answered:

- Why the system needs to be developed?
- Who are the users?
- How will they use the system?
- What are they using the system for?
- What are the input and output of the system?

This question needs to be answered thoroughly to come up with clear functionality of the system describing the functions that the system should perform. All possible requirements of the system to be developed are captured in this phase. After the requirements are understood Software Requirement Specification (SRS) document is prepared to serve as a guideline for the next phase of the model.

4.3.1. Analysis Phase

In this phase analysis of the user's requirement is carried out. This is to determine the scope of the users based on the SRS prepared in the requirement phase and the observations made on the current systems. Thing to be cogitated are

- Scope of users
- Purpose of the system
- Information on surveillance systems
- Suitable equipment's (camera, laptop etc.)

The overall purpose of the analysis phase is to define the project goals that have been determined in the requirements phase into defined functions and operation of the intended system. It analyzes end-user information needs.

4.3.2. Design Phase

This is the plan of how the system will look like and how it works. It describes the desired features and operations in detail and may include screen layouts, process diagrams, pseudocode and other documentation. A sample of the project is developed in this phase. Design focuses on high level design like, what programs are needed and how are they going to interact, low-level design (how the individual programs are going to work), interface design (what are the interfaces going to look like) and data design (what data will be required). During these phases, the software's overall structure is defined and the logical system of the product is developed in this phase. It also helps in specifying hardware and system requirements and also helps in defining overall system architecture (Figure 7).

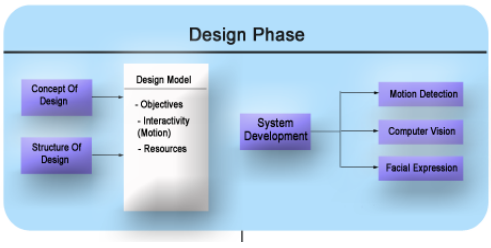

Figure 7: C-WF-SDLC Design Phase

4.3.3. Implementation and Unit Testing Phase

This phase is considered to be the longest phase of the software development life cycle. This is so because this is where the code is created and work is divided into small programs that are referred to as units. This phase include unit testing whereby units will be tested individually for their functionality before the whole system. Unit testing mainly verifies if the modules also known as units meet project specifications.

4.3.4. Testing Phase

This is the main testing phase in the SDLC, as the project is divided in small modules in the previous phase then the modules will be integrated together to test the system as whole. This is to make sure that the modules work together as intended by the developer (as in the specifications) and required by users. It also checks for bugs, errors and ensure the system is able to work in the intended platform. After ensuring that the product had solved the problem the system is then delivered to the customers (Figure 8).

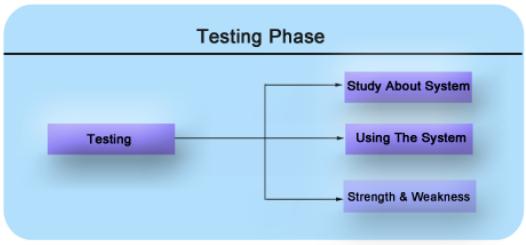

Figure 8: C-WF-SDLC Testing Phase

4.3.5. Maintenance/Operation Phase

Not all problems can be seen directly, but they occur with time and as other problems they needs to be solved. Usually these kinds of problems come in picture after the practical use of the system they are never found throughout the development life cycle. This phase of the Waterfall Model is considered to be very long, it never ends. The changes that occur after the product is handed to the users must not affect the main operation of the system, so a system must be developed in a way that it will adapt to change.

5 Architectural Diagramme

The architectural diagram (Figure 10) shows the flow of events for the facial expression recognition intelligent security system for real time surveillance system. The camera captures the movements concentrating on the head and in the motion detection module the face will be detected together with the head pose estimation. After the face is detected comes behavior understanding of the facial expression. Behavior understanding has two phases: Verification and Identification. In verification phase the system tries to identify the expression detected by reading action units (the dots in eyes, nose, eyebrows and mouth (figure 9). In identification phase, the system attempts to match if the detected and verified expression portrays any feelings that have intentions of doing any prohibited work. [23].

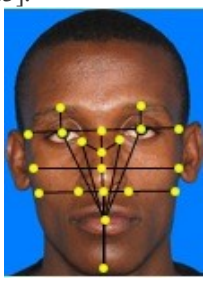

Figure 9: Facial Feature Points/Actin Units

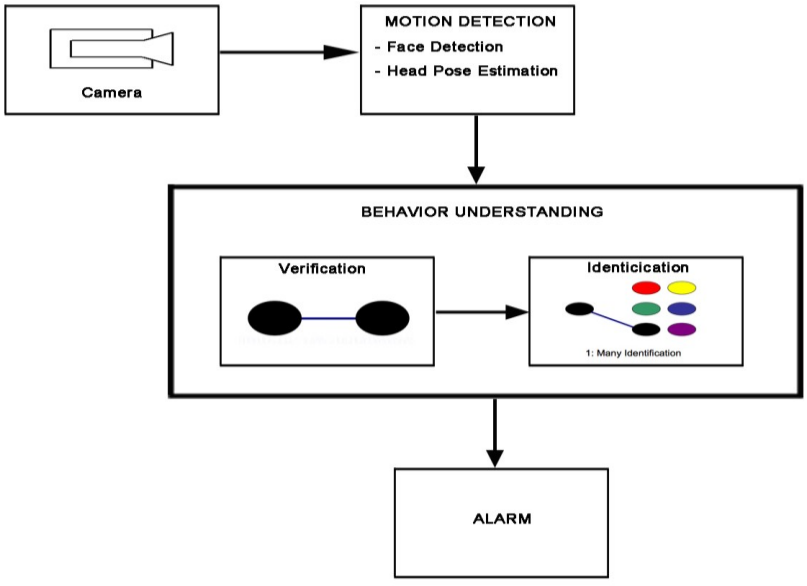

Figure 10: Architectural Diagram of the proposed system

6 Discussions and Conclusion

Facial expression recognition and biometrics can play a major role in preventing many criminal activities from happening. This research covers the design and development of facial expression surveillance system based on the application domain of security surveillance systems and facial

expression recognition. The good thing about the system is that it will be real time, which will make it more effective and reliable for security guards to catch criminals at that particular juncture before they can even get away with the crime.

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