A COMPENDIUM OF PATTERN RECOGNITION TECHNIQUES IN FACE, SPEECH AND LIE DETECTION

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ABSTRACT
Lie is a false statement made with deliberate intent to deceive, this is intentional untruth. People use different technologies of lie detection as Pattern recognition is a science to discover if an individual is telling the truth or lying. Patterns can describe some characteristics of liars, in this work to face and speech specifically. Face recognition take patttern of face and speech recognition of voice or speech to text. So this paper pretends realize a compendium on lie detection techniques and pattern recognition face and speech. It permits to review the actual state of the tecnhologies realized in these recognitions. Also It presents an analysis of tecnhologies using some of these techniques to resum the result.

Keywords: *Pattern recognition, facial recognition, speech recognition, lie detection, digital image processing.*

1. INTRODUCTION

Lying is to make a believed-false statement to another person with the intention that the other person believe that statement to be true. It is the traditional definition of lying. According to its, there are at least four necessary conditions for lying. First, lying requires that a person make a statement (statement condition). Second, lying requires that the person believe the statement to be false; that is, lying requires that the statement be untruthful (untruthfulness condition). Third, lying requires that the untruthful statement be made to another person (addressee condition). Fourth, lying requires that the person intend that other person believe the untruthful statement to be true (intention to deceive the addressee condition) [1]. The story of the lie is imagined opposed to the truth that is the description of something experienced or perceived. *Lie detection* is an important practice that helps in different knowledge areas to identify a truth or a lie of person as psychology, psychiatry, ethology, cognitive science, judicial investigation and traffic flow and computer science [2].

A *pattern* is a set of descriptions or characteristics of a particular object. Patterns are very important because they provide in the identification of a phenomenon or problem and serves as an indicator or model for predicting its future behavior. Some of them allow to detect lies. *Recognition* of these patterns is a science responsable of describe and classify (recognize) objects, people, signals, representations, etc. This science works based on a pre-established set of all possible individual objects (patterns) to recognize. The range of applications of pattern recognition is very wide, but they are related to vision and hearing by a machine, similar to humans usually [3]. Pattern recognition includes several criteria, however we want work about of facial and speech recognition. *Face recognition* is a topic focused on studying e implementing system based on analysis of physical and unique characteristics of each person in his face [4]. *Speech recognition* is the translation of spoken words into text [5].

This paper has been ordered as follows: the section 2 presents some general techniques in lie detection techniques. The section 3 shows pattern recognition techniques in face recognition and speech recognition, the section 4 realizes a compendium in pattern recognition techniques in face and speech for lie detection of this literature consulted and the section 5 concludes and presents future work derived of this theme.

2. LIE DETECTION

Lie detection, also referred to as deception detection, uses questioning techniques along with technology that record physiological functions to ascertain truth and falsehood in response. It is commonly used by law enforcement and has historically been an inexact science [6].
Since XXI century produced advances in psychological techniques that gave way to the *polygraph* to detect lies, measures as blood pressure, pulse, respiration and skin conductivity, tries to find correlation between these measurements [7]. *Torture* was one of the practices most commonly used in ancient times to try to discover the lie of an individual [8]. *The approach Nonverbal behavior indicators* is oriented to detect lies from the behavior of the suspect [9]. Other techniques are *verbals* that focus on the analysis of verbal speech highlighting in *criteria-based content analysis (CBCA)* and *reality monitoring (RM)* based on personal experience of the narrator. There are also

the memories of external origin, examine sensory and semantic contextual information from external event origin imagined [10]. *Scientific content Analysis* (*SCAN)* technique was development in Israel and permits to do a contextual analisys of the statement of the suspect [11]. CBCA, RM and SCAN are written statements can help detect lies but fail by stress, nervousness, anxiety, sadness, shame and fear. These factors can cause alterations in the tests performed on individuals [1]. *Interview* is a method to establish the truth available when a crime is investigated. The information from interviews with victims, witnesses and suspects in some cases can be the only evidence available against the accused. Thorough interview data can be essential to establish the mental state of the person during the material time, and the underlying motive behind the crime. This happens in criminal cases in which there is not enough forensic evidence to convict the suspect [12]. *Guilty knowledge test (GKT)* simply requires that suspects have a memory for details of the crime—precisely where it happened, what the victim was wearing, the weapon used, and so forth. In some respects, the brain-wave GKT is an improvement over the polygraph, but its major problem is that it relies on memory [13]. American Civil Liberties Union (ACLU) declared the polygraph can be deceived in the honesty or dishonesty of an individual diagnostic. The question raised have been object deceit in a test by the use of sedatives, biting the tongue or lips or introduce a tack in the shoe to plunge it in the foot. Nowadays systems to verify truth or lie of a indivual present a degree of unsatisfactory porcentage, the results of polygraph tools is unreliable and most times this is not taken as evidence in court cases [14]. Table 1 presents the principle tecnhiques for lie detection.

Table 1. Lie detection tecnhiques

Aproaches	**Tecnhiques**
Psychological	Torture Polygraph Interview guilty knowledge test (GKT)
Nonverbal behavior indicators	Nonverbal behavior indicators
verbal	criteria-based content analysis (CBCA) reality monitoring (RM) Scientific content Analysis (SCAN)

Also exist technologies to detect lies as *Facial Action Coding System (FACS),* FACS is a research tool useful for measuring any facial expression a human being can make. It is an anatomically based system for comprehensively describing all observable facial movement. It is developed by Paul Elkman, a specialist in facial micro-expressions, during the 1970s and 1980s [15]. Typically, this self-instruction takes 50 to 100 hours. If effort is put into learning FACS five days a week for two hours a day, then learning will be closer to 50 than 100 hours [16]. *Face Reading Technology for Lie Detection* from Ugail, Yap and Rajoub with standard video camera and High resolution thermal camera, that indicates an individual is experiencing a particular specific emotion is hard to determine [17]. *Voice stress analysis (VSA)* technology is said to record psychophysiological stress responses that are present in the human voice when a person suffers psychological stress in response to a stimulus (*e.g.*, a question), and the consequences of the person's answer may be dire. This has sevel versions [18]. *The psycholological stress evaluator (PSE)* was produced and sold by company (Dektor) formed by three former police officers (Bell, Ford and McQuiston) in the early 1970s. *The Diogenes digital voice stress analysis* program has been produced to detect, process and display changes in voice pattern using the microtremor. The microtremor in laryngeal muscles are to reflect the level of stress being experienced by individual due to deception [19]. *Layered Voice Analysis (LVA)* is develeoped by Nemesysco [20] and is based on the technology of vocal stress analysis, is very simple program Visual Basic [21]. Some tecnical details like variable declarations are ommitted, but the complete program is unlikely to comprise more than 800 or so lines, this program is based neural networks [19]. Differents software aplications exist too in lie detection to analize the face, eyes and voice based in polygraph, according to the opinions of users it is not of good performance like *Truth and Lie Detector Scanner on the App Store on iTunes* or *lie detector on Android*. These tecnhologies present a degree of unsatisfactory porcentage in reliability of the response [14].

3. PATTERN RECOGNITION

Pattern recognition has its origins in engineering, and the term is popular in the context of computer vision. In pattern recognition, there may be a higher interest to formalize, explain and visualize the pattern. Some domains have evolved substantially from their roots in artificial intelligence, engineering and statistics; and have become increasingly similar by integrating developments and ideas from each other [3]. Particularly visual and sound patterns. It is face and speech recognition.

3.1 FACE RECOGNITION

Face Recognition System (FRS) in computer science is process can be subdivided into two main parts. The first part is image processing and the second part is recognition techniques. The image processing part consists of face image acquisition through scanning, image enhancement, image clipping, filtering, edge detection and feature extraction [22, 23]. The second part is the face recognition, it is a computer technology that determines the location and size of human face in arbitrary digital image [24].

Different face recognition techniques have been proposed based on models and images that provide a first look at what was once only possible for the human eye. *The three-dimensional vision* is part of the compute vision using the three-dimensional properties of a real scene inferred digital images 2D, 3D, video to make an interpretation on it. In this case, the pattern to recognize is the human face [2]. *Elastic Bunch Graph Matching (EBGM*) employs an algorithm that focuses to determine points of interest in the face to allow facial recognition tasks [25]. EBGM tecnhique has 2 stage: The first is to set a graph main points in the face, using a statistical model of the graph and the second stage extracts local characteristics at these points and finds the distance between the graph obtained and its descriptors to identify the person [26]. *Neural networks* are mathematical models based on the operation of biological neural networks from nervous system. It comprises a set of processing units called neurons, cells or nodes, interconnected by several bands of direct communication, called connections, in order to receive input signals, process them and issue output signals. One of the most important applications of artificial neural networks is pattern recognition, for face detection process training a neural network is a very difficult task as the problem arises in characterizing prototypical non-facial images [27]. *The Fuzzy Pattern Matching* uses fuzzy theory to representing diverse, non-exact, uncertain, and inaccurate knowledge or information. And information carried in individual fuzzy set is combined to make a decision [28, 29]. A new method to detect faces in color images based on the fuzzy theory is proposed where two fuzzy models are used to describe the skin color and hair color respectively. Where a uniform color space is used to describe the color information to increase the accuracy and stableness [30]. Other tecnhique is *Principal Component Analysis (PCA)* or *Eigenfaces* or *Eigenvector* where faces can be easily reconstructed by considering only a small amount of information obtained [31, 32, 33]. *Fourier transform* analyzes a signal for its frequency content. *Radon transform* is transform where a mapping from the Cartesian rectangular coordinates (x, y) to a distance and an angle, polar coordinates. *Gabor wavelets transform* is a wavelet-based transform which is used for feature extraction, provides the optimized resolution in both time and frequency domain for time-frequency analysis [34]. *Fuzzy invariant vector* after extracting an invariant feature vector is extracted, it is converting into a fuzzy invariant vector which increase discrimination and decrease the impacts of low-frequency noise. *Adaptive Resonance Theory (ART)* is compatible with the human brain in processing information. ART can learn and memorize a large number of new concepts in a manner that does not necessarily cause existing ones to be forgotten. *Markov random field (MRF)* model is used as classifier for pattern recognition, which combines statistical and structural information. States, Only the best set of states, are used to design model the statistical information, and the relationships between states represents structural information. These five ultimate techniques analyze features. *Support Vector Machine (SVM)* can handle linearly separable data as well as non-linearly separable data using kernel functions. The kernel function such as polynomial, Gaussian radial basis function, exponential radial basis function, spline, wavelet and autocorrelation wavelet kernel, can map the training examples in input space into a feature space. *Multi-class SVM* can be preferred as a meta-level learner. Multi-Classifier system is higher classification accuracy, based on SVM for pattern recognition. This combinational strategy classifier is based on stacked generalization which combine classifiers from different learners, having a two-level structure [35]. These techniques have been analyzed from two approaches: *based on facial features* or *local nature approaches*, which seek certain elements of the face such as the eyes, nose and mouth; *holistic approaches* or *based on the image*, in this case the methods work with the whole image or specific areas from which features are extracted that can represent the object sought [36]. Table 2 resumes the classification of face recognition techniques of the work presented in this section.

Table 2. Face recognition technique

Approaches	**Tecnhiques**	
Based on facial features or local nature	Elastic Bunch Graph Matching (EBGM)	Elastic Bunch Graph Matching (EBGM)
	Low Level Analysis	The Fuzzy Pattern Matching Fuzzy invariant vector
	Feature Analysis	Gabor wavelets transform, Fourier transform Radon transform Adaptive Resonance Theory (ART) Markov random field (MRF)
Holistic or based on the image	The three-dimensional vision	The three-dimensional vision
	Neuronal network	Neuronal network
	Statistical	Eigenfaces, Eigenvector or Principal Component Analysis (PCA) Support Vector Machine SVM Multi-class SVM

The previuos works indicate a great effort in technology advances in face recognition. Some researchers had worked with other previous techniques like *Active shape* for feature extraction, however this paper present an actual state.

3.2 SPEECH RECOGNITION

In computer science, speech recognition (SR) is the translation of spoken words into text. It is also know as Automatic speech recognition (ASR), computer speech recognition or speech to text (STT). Some SR Systems use speaker independent speech recognition while other use training where an individual speaker reads sections of text into the SR system. These systems analyze the person's specific voice and use it to fine tune the recognition of that person´s speech, resulting in more accurate transcription. Systems that do not use training are called speaker independent systems. Speech recognition applications include voice user interfaces such as voice dialling, call routing domotic appliance control, search (e.g. find a podcast where particular words were spoken), simple data entry, preparation of structured documents, speech to text processing (e.g., word processors or emails), and aircraft [5].

Some speech recognition techniques are: *Support Vector Machine (SVM)* have proved to be pattern classification tools with a strong connection to statistical learning tecnhiques. One of the hurdles to using SVM in speech recognition, is the choice of the kernel fun tion for non-separable data, and the setting of its parameters [37, 38]. *Augmented conditional random fields (ACRFs)* are flexible acoustic models specifically designed to take advantage of context information in an augmented space [39]. ACRFs incorporate acoustic context information into an augmented space in order to model the sequential phenomena of the speech signal [40]. Automatic speech recognition systems use *Hidden Markov models (HMM)* to model the temporal variation, with local spectral variability modeled using flexible distributions such as mixtures of Gaussian densities. HMM can divide the acoustic space into a large number of small dense regions, assigning these regions to a large number of labels, or states, a process that is not unlike (soft) vector quantization and directly related to the definition of a pattern classification problem [41]. *Minimum Phone Error (MPE)* is a previously introduced technique for discriminative training of HMM parameters [42]. *High-dimensional feature generation* in *feature Minimum Phone Error (fMPE)* applies the same objective function to the features, transforming the data with a kernel-like method and training millions of parameters, comparable to the size of the acoustic model [43]. *Neural networks* emerged as an attractive aproach, neural networks have been used in many aspects of speech recognition such isolated word recognition and speaker adaptation [44]. In contrast to HMM, neural network make no assumptions about feature statical properties and have several qualities making them attractive recgnition models for speech recognition. When used to estimate the probabilities of speech feature segment, neural networks allow discriminative training in a natural and efficient manner. Few assumptions on the statistics of input features are made with neural networks. However, in spite of their effectiveness in classifying short-time units such as individual phones and isolated words [45, 46, 47] neural networks are rarely succesful for continuous recognition tasks, largely because of their lack of ability to model temporal dependencies. Thus one alternative approach is to use neural networks as pre-processing e.g feature transformation, dimensionality reduction [48]. The table 3 consolidates some speech recognition techniques reviewed.

Table 3. speech recognition technique

Approaches	**technique**	
Feature	Acoustic context	Augmented conditional random fields (ACRFs) Hidden Markov models (HMM)
	Feature Analysis	High-dimensional feature generation feature Minimum Phone Error (fMPE) Minimum Phone Error (MPE)
Holistic	Neural networks	Neural networks
	statistical	Support Vector Machine (SVM)

4. DISCUSSION

Between literature studied in the section 2 and 3 showed various pattern recognition techniques in face, speech and lie detection tecnhiques. Also it presented some technologies that apply this techniques to detect lies. The next table you can to see an analysis about of some lie detection technologies in relationship with pattern recognition techniques in face and speech, few have face recognition and the most recognition technique used is the psychological approach. Important is mention there are some other works in face and speech recognition but not to detect lies, e.g. apps of face recognition is apps for social networks to tags but it is not used to detect lies [49]. Technologies could improve using several pattern tecnhiques in face and speech because each technique focuses in only recognition.

Table 4. Analysis lie detection technologies

Lie detection technologies	**Face recognition**	**Speech recognition**	**Recognition technique**
Facial Action Coding System (FACS)	Yes	No	Psychological
Face Reading Technology for Lie Detection	Yes	No	statistical
Voice stress analysis (VSA)	No	Yes	Psychological
The psycholological stress evaluator (PSE)	No	Yes	Psychological
The Diogenes digital voice stress analysis	No	Yes	Psychological
Layered Voice Analysis (LVA)	No	Yes	Neuronal network

You can observe that exist individual technologies in face and speech but not to both. The table 5 gives an analysis of pattern recognition techniques where only two tecniques permit works face and speech SVM and neuronal network. This means that most of techniques are designed only for the face or speech. With a method applying both recognition, person can take more pattern and improve percentages of satisfaction in lie detection. To detect lies

Tabla 5. Analysis of pattern recognition techniques

Technique	**Domian of aplication**	
	Face	**speech**
Elastic Bunch Graph Matching (EBGM)	Yes	No
The Fuzzy Pattern Matching	Yes	No
Fuzzy invariant vector	Yes	No
Gabor wavelets transform	Yes	No
Fourier transform	Yes	No
Radon transform	Yes	No
Adaptive Resonance Theory (ART)	Yes	No
Markov random field (MRF)	Yes	No
The three-dimensional vision	Yes	No
Neuronal network	Yes	Yes
Eigenfaces, Eigenvector or Principal Component Analysis (PCA)	Yes	No
Support Vector Machine SVM	Yes	Yes
Multi-class SVM	Yes	No
Augmented conditional random fields (ACRFs)	Yes	No
Hidden Markov models (HMM)	Yes	No
High-dimensional feature generation	Yes	No
Feature Minimum Phone Error (fMPE)	Yes	No
Minimum Phone Error (MPE)	Yes	No

5. CONCLUSIONS

This paper presented a review about of lie detection and pattern recognition in face and speech. Also it showed some technologies that aplicate this tecniques to detect lies. Face recognition is indeed a difficult problem as faces can vary a great deal in their orientation, facial expression and lighting conditions, this requires use other techniques and take other pattern as speech recognition. Over the years researchers have created technologies and techniques to detect lies but they still have problems with the help of pattern recognition for face and speech in the same scenario the percentage of satisfaction would improve and results could be trusted. As future work intent to take differents pattern recognition in face and speech using a tecnhique for both and permit detect lies throught digital image processing for face and computational linguistics especifically in speech to text (STT) for speech. So with this patterns create a method with a prototype.

6. ACKNOWLEDGEMENTS

Acknowledgements sincerely to Tecnologico of Antioquia University of Medellín for their support in the project «Lie Detection from patterns recognition in face and speech using computational linguistics and digital image processing» in which is focused this paper.

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