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Evaluation of Lie Detection Techniques: Overview

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ABSTRACT

Recently, the need to separate truth from lies has motivated lie detection as a constant human endeavor; therefore there is a need to develop lie detection techniques and focus on the new area of lie detection utilizing facial expression. Human faces are a powerful repository of emotions in the complicated interaction between verbal and non-verbal clues that characterize human communication. From this micro-expression, the transitory emotion discloses the more prominent indicators that precede deceitful behavior, which makes the tapestry rich in information that can be harnessed to detect a lie. Historically, the development of deceiving lies passed through many developments to find the best way to get high performance, but the development of artificial intelligence and face recognition has further altered the landscape of lie detection. In this paper, the reason for lie detection is revealed with the techniques used to detect lies. The paper aims to present and survey the techniques with comparison used to detect lies, which will highlight the importance of this topic and urge researchers to develop current techniques or find other related techniques that serve the issue. The presentation of the techniques in this research revealed that the lie detection technique using facial expressions is considered the best technique to achieve the detection of lies. Facial expression is the most efficient because it does not require physical contact and because they are visual of real internal feelings and not voluntary movements, and computer vision and artificial intelligence have had an effective role in supporting this method and exploiting it optimally. Finally, the paper shows the limitations and achievements that the researchers found in their research to help researchers in this field.

1. INTRODUCTION

The human can differentiate truth. Scholars, scientists, and investigators have been fascinated by the phenomenon of deception for ages, regardless of whether it is motivated by self-preservation, self-interest, or a variety of other factors. The desire to uncover the hidden and reveal the truth beneath a curtain of lies has sparked the examination of numerous techniques and tools designed to detect deception's subtle signals. The ability to detect lies in people's comments and behaviors has become one of these tools, and lie detection is a growing subject of study and practice. Over the years, we have discovered the importance of detecting lies in many places [1, 2]:

1. Criminal investigation and law court where it is important to present lie detection evidence using a lie detection method or expert testimony of facial expression [3, 4].
2. Border control, which is needed at border crossings and airports to identify those exhibiting questionable conduct or giving lie information [5-7].
3. Employment and workplace, where we use it in interviews and workplace investigations [8].
4. Therapeutic assessment and forensic psychology, where psychologists and therapists need to assess the emotional states and truthfulness of clients, aiding in the diagnosis and treatment of mental health, also use the lie detection method in situations including testimony from witnesses or assessments of people's mental states [9].

Intelligence and counterintelligence are where we used to find spies, moles, or people with dual loyalties within their organization [10].

Consumer protection and fraud prevention are where financial institutions and consumer protection organizations can spot fraudulent behavior like identity theft or dishonest business practices [11].

Finally, use it in academic research and experimental studies where we use methods to study the behavior of humans and nonverbal communication and measure the impact of deception on human behavior [12-15].

This paper addresses the age-old question, "Can deception truly be unraveled, or will it forever remain an enigmatic facet of the human experience?" We explore various lie detection techniques, highlighting their pros and cons, and focus on facial expression analysis. The goal is to guide researchers in applying artificial intelligence methods to enhance and expand datasets in this area.

2. LIE DETECTION TECHNIQUES

This makes it important to detect lies [2, 16, 17]. There are five techniques to detect lies, and each method has advantages

and disadvantages Table 1 shows that each technique has its approach and principles for assessing deception or truthfulness.

Table 1. Lie detection techniques comparison

Techniques	Working	Accuracy	Advantages	Problems
Polygraph method	It identifies stress related reactions such as increase in skin conductivity, heart rate, breathing rate and BP (blood pressure).	Studies in this field vary considerably, which shows 60 to more than 90 percent accuracy.	Cost of the system has decreased due to competition in the market.	Human can experience stress for many reasons: Tension, annoyance, pain, fear, surprise. 2. An expertise need to read the graphs
Voice-stress analysis method	This needs a computer program which determines variations in speech patterns, such as tone, pitch and intensity, stress, which may imply deception.	Uncertain	*Not required any direct contact with the subject. *Ease of use, only a microphone required to attached to the subject.	*Found stress better, than a lie but if it is a good lie detector it remains unclear.
Micro-expressions	Popularly working on facial movements which can reveal range of emotions, including however a person is trying to hide	Highly accurate	*Not required any intervention with the subject. *Could be used secretively by videotaping *High precision	Availability of datasets *Compound expressions
Functional MRI	fMRI signifies changes in the brain activity based on the concept that when people lie, they shows greater changes in blood flow rate.	Unclear	*FMRI has no risk, as it does not use radiations like X-Rays. *It can evaluate brain function safely.	*It is expensive *fMRI scan difficult to interpret. *Researchers still don't completely understand how it works. *High initial cost.
Thermal imaging	It measures the surface skin temperature accurately.	Accurate for measuring surface skin temperature.	*Works well without Physical interaction. *It can act as a cue to detect deceit.	*High temperature may be the reason of many other causes which may produce wrong results. *Environment sensitive

2.1 Polygraph method (polygraphy)

Used to measure physiological responses such as heart rate and blood pressure while the device connects to the skin while the person answers the question, the advantages of this method are that it can be widely used and that real-time monitoring makes the investigators and jurors understand, while the challenges are that psychological stress may produce a false result and skilled people may influence the outcomes, making it difficult to detect lies [18] (Figure 1).

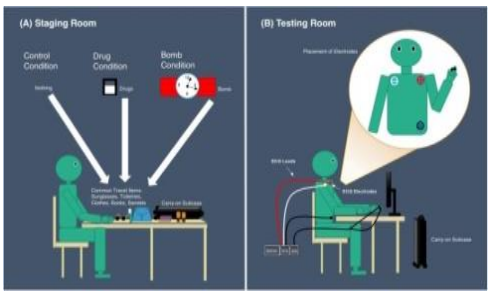

Figure 1. Classical polygraph method [19]

2.2 Voice stress analysis method (phonoscope)

Non-invasive and does not need to require physical control, the advantage of this method is that it can provide real-time results during speech, and it's useful in interviews and interrogations. While the challenges are limited in scientific support, this means that many studies have failed to demonstrate consistent and accurate results using this method, and changes in vocal characteristics can result from factors such as nervousness or illness [20] (Figure 2).

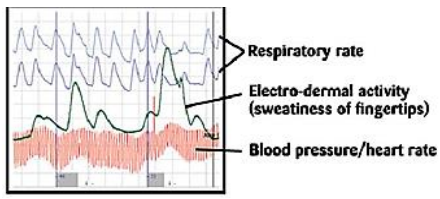

Figure 2. Stress analysis method [21]

2.3 Brain imaging methods

Non-invasively examine the brain's anatomy, physiology, and neural activity. It is used to visualize and study the structure, function, and activity of the brain. The advantages of this method are that it provides information on the neurological mechanisms involved in deception as well as unbiased, potentially less manipulable data on brain activity. The disadvantages are that this method is complex, costly, and typically not suitable for real-time or field applications. Also, it is limited due to the need for specialized equipment, controlled environments, and expert analysis, and finally, brain imaging raises ethical concerns related to privacy, consent, and the potential for misinterpretation of brain data [22, 23] (Figure 3).

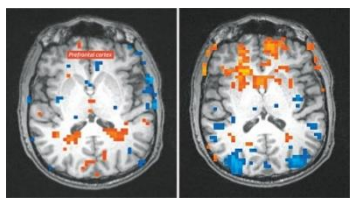

Figure 3. A change in the brain when lying [24]

2.4 Thermal imaging method

Non-invasive, it uses infrared technology for the detection and visualization of the heat patterns emitted by the human body. The advantage of this method is that it can record changes in skin temperature and blood flow and offer real-time feedback when a person answers questions or converses with others, while the disadvantage is that stress can lead to skin temperature and blood flow changes. These changes are not caused by lying; they may be caused by nervousness or discomfort during the process. Environmental factors may influence skin temperatures, such as room temperature and humidity, and various outside temperatures lead to various thermal imaging readings. Since there aren't any established standards or recommendations for employing thermal imaging to identify deception, it might be difficult to create consistent and trustworthy procedures. Finally, thermal imaging can be used as an additional tool in conjunction with other methods to produce more data for analysis [25] (Figure 4).

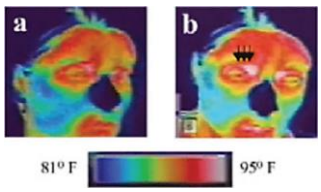

Figure 4. Thermal imaging [26]

2.5 Micro-expression method

It involves the systematic examination and interpretation of facial expressions to gain insights into an individual's emotional state, intentions, and non-verbal communication. This analysis is based on the idea that human faces convey a wide range of emotions and subtle cues through changes in facial muscle movements and expressions. The advantage of this method is that it is considered to be an authentic indicator of someone's mental state. It represents the person's true feelings, as opposed to consciously controlled facial expressions, which may be used to conceal emotion. It is involuntary and typically occurs without the person's awareness or control; it does not require physical contact or equipment attached to the person being tested. Micro-expressions are extremely brief, often lasting just a fraction of a second (as short as 1/25th of the second). This brevity can make them challenging to detect with the naked eye. The disadvantages are that human observers may introduce subjectivity into the analysis and different experts may reach different conclusions. Also, the interpretation of facial expression depends on the context, which can be complex to establish. In addition, facial expressions can vary across cultures interpreting challenges in cross-cultural situations (Table 2) [27].

According to technique analysis for multiple studies, the best method is micro-expressions for their advantages compared with the other techniques.

Table 2. Micro-expression method example [27]

AU	Description	Facial Muscle	Example Image
1	Inner brow raiser	Frontalis, pars medialis	
2	Outer brow raiser	Frontalis, pars lateralis	
4	Brow lowerer	Corrugator supercilii, depressor supercillii	
5	Upper lid raiser	Levalor palpebrae super ioris	
6	Cheek raiser	Orbicularis oculi, pars orbitalis	
7	Lid tightener	Orbicularis oculi, pars palpebralis	
9	Nose wrinkler	Levator labil superioris alaqu ae nasi	

3. LIE DETECTION USING MICRO-EXPRESSION

According to previous studies, micro-expression is the best method to detect lies [2], so new approaches and algorithms have been created, and the development of artificial intelligence has produced a blatant advancement in the realm of research [6]. There is a different way to detect lies using micro-expression. This paper provides the findings of studies that use images and videos, where all studies use the supervised method. Table 3 shows the studies that use images and videos. The table shows the algorithm that the research uses, the data set, the target, and the achievement.

Table 3. Micro-expression lie detection studies

Algorithm	Field	Dataset	Target	Achievement	Ref.
CNN and Random Forest classifier	Video game	Self-made dataset based on game	Detect lies using AI	Random forest outperformed CNN with this model's 86% accuracy.	[28]
OpenFace	Evidence:	Employ 61 fraudulent	Data-driven automated	Truth video has 81.1% accuracy,	[29]

	Visual Lexical Acoustic	and 60 true video sources.	deceit detection	whereas deception video has 76.20%. It automatically recognized gestures and mapped textual analysis. CNN was less accurate than Random Forest at 86%.	
Mathematical algorithm Video frames Embedded vision system	Video	Video made by a high-speed camera	lie detection	The expression recognition accuracy is 85%.	[30]
3D CNN	Video	Samples from: •SMIC •SAMM •CASM II	extracted high-level features with details of micro-expressions.	UAR is 0.7605 and UF1 is o.7353, which exceeds the most current state-of-the-art models.	[31]
Classifiers of threshold-base	Thermal images	Interview video	Crime investigation lie detection	Blind predictions yield 80% for a method that employs thermal imaging to assess the quantity of sweat on the face induced by stress.	[32]
Deep CNN and feed those characteristics to LSTM	Video	Video from a spontaneous database	Evaluate the prosed network model TLCNN	TLCNN is better than some state-of-art	[33]
HAAR Cascade algorithm in Matlab	Video image	Create continuous video using a Mathlab-connected camera.	•Detect lie •Drivers test	When the flash pattern matched the target contrast pattern, the person in question was determined to be lying.	[34]
Random Forest	Video	Open-source datasets like YouTube	Forensic interview to identify four treatments (eye blink, eyebrow motion, wrinkle incidence, mouth motion).	Use computer vision to detect high-risk fraud using facial vale	[35]
Utilizing approaches based on 2D appearance to describe 3D face features	TV program (video)	non-public dataset of real (genuine) and posed (deceptive) face expressions.	Lie detection	Computer vision methods provide 76.92% accuracy in facial signals for lying detection in high-stakes situations.	[36]
Underlying 2-layer GRU DepLie	Video	Kaggle has FER-2013 faces with emotions and humans talking truth or lies video	Lie detection	The validation set's correct classification rat (CCR) is 81.82%, the training set's 94.31% and 25 leave-one-out cross-validation trials get it to 100%.	[37]
AUS	Video and computer vision	satisfied and spontaneously dataset.	•Security national •Clinical field	Micro-expressions intensity Emotion marking standards Rapid facial expressions	[38]
MVL	Video	Public multimedia sources from TV interviews and court trials	Deception detection trouble	Multi-view learning deception detection increases classification above current methods.	[39]
Self-supervised learning with MobileNet2	Online lecture	CelebA(available on the net for free) for pre-training Self-made for testing	A multimodal system can detect liars	an AI strategy to help instructors address this developing problem for a fairer learning environment	[40]
Tow classification algorithm: Decision trees Random FOREST	Video	Public court video dataset	Compear between the two algorithm	found Random Forest is better than Decision trees	[41]
Shallow CNN	Image	Use five open datasets: •SAMM •CASMEII •CASME •FERPlus •FER2013	Detect micro-expressions: Lie, Pain, and Babysitting	aSHCNN architecture without temporal can detect static expressions without huge datasets and provide increased saliency map	[42]
HAAR-LIK feature-based cascade classifier	Video	Interview video	Indicating by psychological	The result shows excellent nonverbal behavior detection.	[9]
Facial emotion recognition using convolutional neural network	Image	Extended Cohn-Kanade Caltech faces CMU NIST	Detect lie Learn based on mood	The accuracy of FERC is about 96%.	[43]
Deep Tiefes FCNN	Image	Kaggle dataset	Deception detection	Tiefes FCNN for micro facial expression: 99.02% accuracy, 98.82% precision, 97.8% F1-score,	[44]

Multi-model detector	Video	Real-life video	Lie detection	56.31 PSNR, 96.31 CC. It uses high-level and low-level visual characteristics to predict dishonesty independent of identification.	[45]
Face reader	Video	Videotape	•Child lie detection •Psychology forensic implications	automatically decipher the lying child's face and correlate it with lie detection.	[46]
Shi-Tomasi corner	Image	Collected data from 30 various scenarios and subject	Interrogaitions rooms Airports	The combined thermal and visual classifiers achieved an accuracy of 61.74% and 59.73%, outperforming physiological characteristics by 53.02% and reducing error rates by 18.56% and 14.28% respectively.	[47]
Micro-expression training tool (METT)	Video	Different types of video	Improve detect lie	The METT group did not outperform those in the bogus untraining and training groups when using Bayesian analyses.	[48]
Kanade-Lucas-Tomasi algorithm	Video	Use two datasets: •CASMEII •SMIC	Propose a local binary pattern and optical flow histogram approach for using MEs on huge videos.	automated micro-expression, system analysis identifies MEs.	[49]
Lightweight pre-trained CNN call ResNet 18	Image	FER-2013 dataset	Detect lie	Detect the fear from the liar's face	[50]

The limitations the researchers found in the previous studies are that users are not professionals in lie detection, the amount of dataset is small, and not every dataset is public for the users. Finally, the way to record video and get pictures is clear; in other words, uncontrolled facts like head pose, illumination, and facial occlusion.

Although analyzing facial microexpressions is important for lie detection, it raises ethical concerns and privacy issues because it can be misused in different ways. Microexpressions, which are involuntary and fleeting, promise to reveal individuals' true feelings even when they try to hide them, thus violating emotional privacy [51, 52]. Artificial intelligence techniques such as deep learning in micro-expression recognition lead to the detection of real emotions, which violates personal rights as it makes emotional displays. This highlights the need to address the ethical implications and prevent potential misuse of this technology [53]. These concerns are particularly important in scenarios such as national security, clinical diagnosis, interrogations, and business negotiations where partial expression analysis is applied [8]. According to what was mentioned above, it is necessary to educate researchers about the necessity of preserving privacy and warn them of the resulting legal consequences and penalties, as well as educate individuals about the necessity of taking pledges from data set collectors not to use their data except for scientific purposes and to preserve their privacy. Finally, maintaining the confidentiality of data and using these technologies for humanitarian purposes and to serve society.

4. CONCLUSIONS

This paper shows the reason for using and developing lie detection and the techniques used to do that, and then it focuses on the best technique and shows what researchers do to develop the way to detect lies using facial expressions by showing the methods, dataset, field that the researcher uses either image or video, target, achievement, and finally the limitation that the researchers found in their research, which may be scientific, technical and ethical limitations. This paper exploited its presentation of these limitations to help researchers deal with, treat, and solve them by finding new methods or techniques or choosing a different dataset. Artificial intelligence plays an effective role in enhancing the lie detection process, and its multiple techniques and methods are considered the most important for effective detection in the micro expression method. However, the clarity and accuracy of the source, whether it is a video or an image, significantly affect the results, so this paper advises researchers in this field to take this point into account by enhancing image and/ or video quality using preprocessing techniques, in addition to providing a suitable data set. Finally improving the user of the lie detection method through effective and accurate training will significantly enhance the detection results.

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