

ARTICLE

Artificial Intelligence based Approach to Analyze the Lie Detection using Skin and Facial Expression

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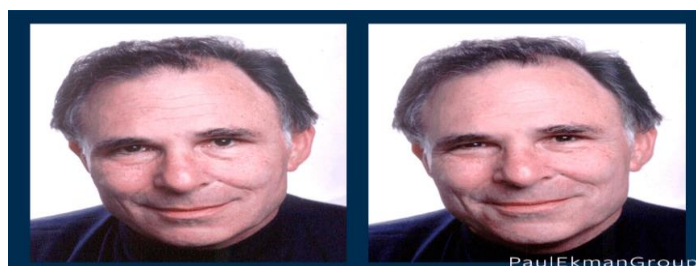
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ABSTRACT: Finding a secret fact that is known to one person but kept from others is the aim of lie detection. When it comes to security and legal concerns, it is crucial to be able to analyze human deceptive behavior. Based on the idea that lying causes specific emotions, which in turn cause certain physiological reactions depending on a person's level of stress, psychological lie detection is based on this premise. Modern lie detectors measure things like skin conductance, respiration, and blood pressure. The intended study presents a lie detection system that uses fuzzy analysis to integrate many factors, including skin conductance, facial expressions (eye blinking), and voice frequency, which is actually influenced by a person's degree of stress. Fuzzy is an AI technique based on graphical representations and mathematical calculations of an output which is affected by input parameters. In comparison to employing a single indicator alone, the integration of skin analysis, voice level, and facial expression using fuzzy analysis may improve the accuracy of lie detection. This analysis provides a way to predict that a person is lying when all three parameters i.e., Skin conductance, voice frequency, and blinking of eye increases which effect on stress level of a body.

Keywords: Lie detection, Skin conductance, Facial expressions, Voice frequency, Fuzzy logic

Introduction:

In "psychology and law," one of the main subfields of applied psychology, lie detection is a key issue. It is not difficult why it is crucial to determine whether someone is telling the truth or lying in court proceedings, border control interviews, intelligence interviews, and other situations. Psychologists and other professionals have created a variety of lie detecting tools to help with the process. These instruments cover the full gamut of what is conceivable, from observing and measuring skin conductance level and to analyze the facial expressions [1]. Facial micro-expressions are a key aspect of interpersonal communication and convey valuable insights into human emotions, thoughts, and mental states [2].



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Fig 1: A happiness expression is false is when the eye muscles are not involved when smiling [3].

The goal of lie detection is to discover a secret fact that is kept a secret from others but known to one individual. The basis of the polygraph, a technique for psychophysiological detecting lies, is the notion that lying causes particular emotions, which have observable physical effects [4].

For some practical issues, a fuzzy system offers a more accurate approximation. The fuzzy system has been used in a number of current BCI works and has demonstrated increased system performance. It has also been combined with other ways, and when used alone, it performed just as well [5]. Lie detector tests are crucial due to their numerous practical applications. Crime investigation units, national security organizations, business, and industry are a few of the key organized industries that utilize lie detection testing [6].

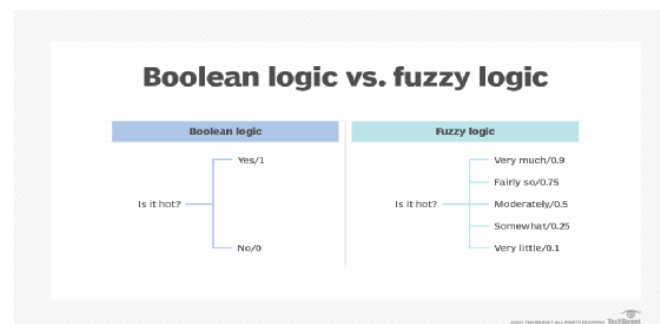


Fig 2: Comparing the degrees of truth with Boolean logic vs. fuzzy logic [7].

The eye movement will also be tracked and observed concurrently. Several experiments shown those liars' eyes movement differ from those of innocent people [8].

I. *Dilated Pupils*, which are connected to heightened anxiety and a burden on the working memory [9].

II. *The Strategy of Avoidance*, when the individual tries to avoid looking at the "crime object" and concentrates more on the neutral objects [10].

III. *Change in the Blinking Rate*, The number of blinks is lower when a person is lying than when they are in their natural state, but after the lie has been spoken, the number of blinks rises sharply [11].

According to psychological science, dilated pupils are a sign of depression, which includes lying, thus they can be a great way to tell if someone is lying or not. The frequency of eye blinking can sometimes be a sign of deceit. Based on the results of a lie detector experiment [12, 13].

Traditional analog polygonal instruments typically record SR skin conductance, whereas academic psychologists typically record SC skin conductance and argue that SC is superior to SR [14]. The findings show that this type of training greatly increases the body's response to lying [15]. There are many others techniques to find out the deception such as, The electroencephalographic (EEG) variability and fuzzy theory are used in this research to construct a lie detection model and rule set that identifies sensitive and useful EEG frequency bands to precisely quantify lying states based on spectrum analysis [16]. A fuzzy relational method to manage and interpret face manifestations of human emotion. The proposed approach involves evoking specific emotions in human volunteers via an external stimulus, and then segmenting and identifying the individual frames into areas of interest to analyze the facial expressions [17].

The vision-based human-computer interaction is also a efficient technique in the detection of lie. Intentional eye blinks are recognized as control commands by the interface. The image processing methods used include their-like characteristics for automatic face detection, template matching-based eye tracking, and eye-blink detection [18].

High stakes circumstances can be uncomfortable, whether one is telling the truth or lying. But according to the "leakage theory," the dread of being discovered is almost impossible to control in liars, who may feel it more than truth-tellers. Because of this, we assumed that analyzing a person's terrified facial expression could reveal lying [19].

Fuzzy Logic Simulation for Lie Detection

The fuzzy analysis tool in MATLAB was utilized for analysis and a parametric estimate. The fuzzy logic controller (FLC) can function with two inputs and two outputs. Investigated are both the effects of the input parameters and the effects of real-world situations on the output parameters. MATLAB fuzzy Rule-Based System is used in order to predict the impact of various parameters on the detection of Lie and stress level in investigation. Fuzzy analysis to predict the impact of skin conductance level, blinking of eye, voice frequency, linguistic analysis, body movement and EEG (Electroencephalogram) on lie detection and stress level.

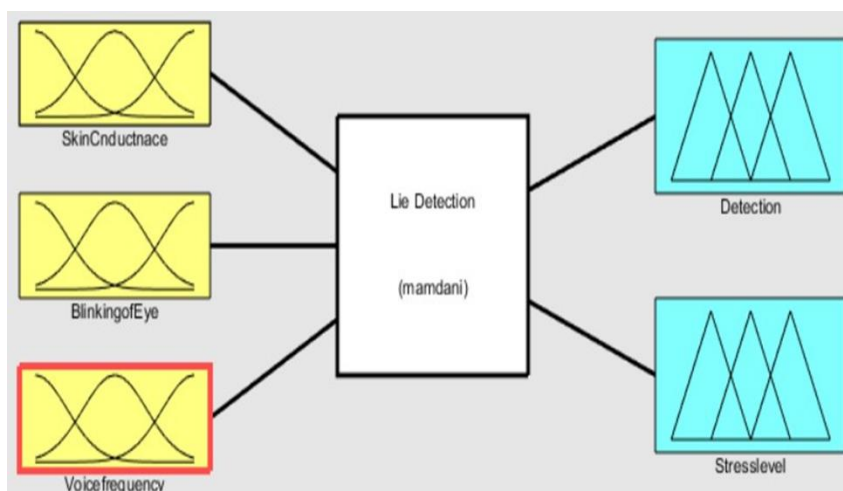
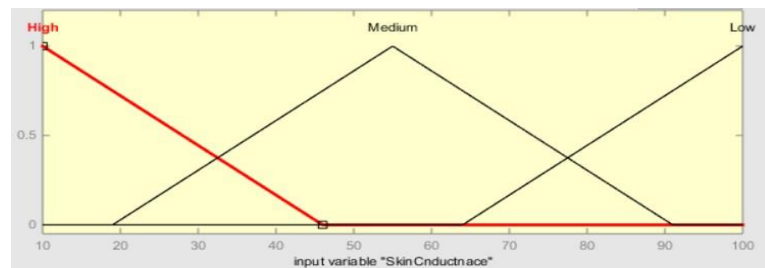
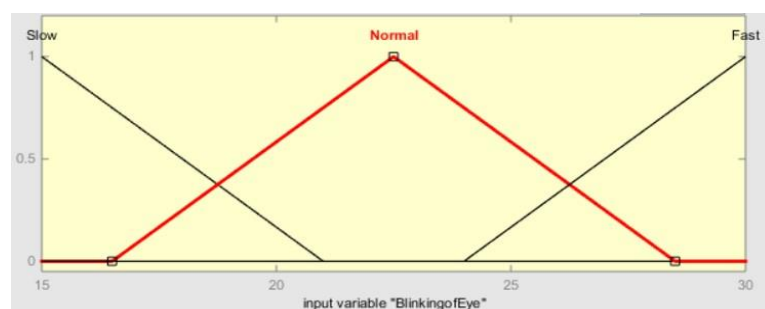


Fig 3: FIS figure of the parameters and its impact on the detection of lie and stress level

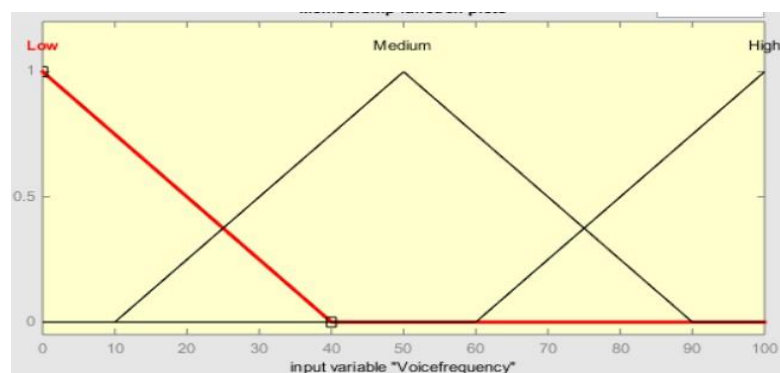
The fig 3 describe the fuzzy inference system for lie detection having 3 inputs including skin conductance level, facial expression (blinking of an eye), and voice frequency with coressponding output parameters detection and stress level. FIS is te key unit of a fuzzy system hsving decision making as its primary work. It uses the "IF THEN" rule. The mapping of the given input values to an output using fuzzy logic.



4(a)



4(b)

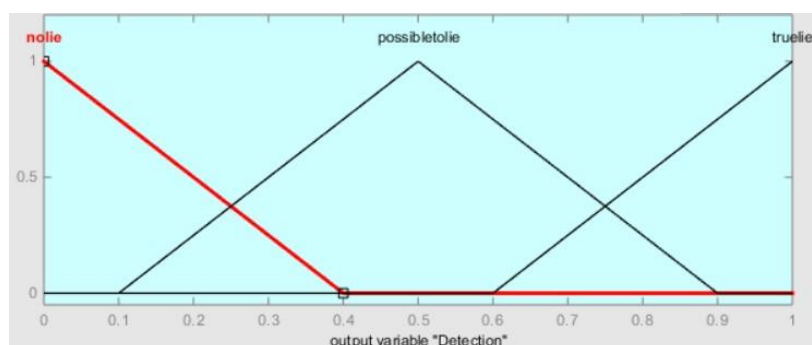


4(c)

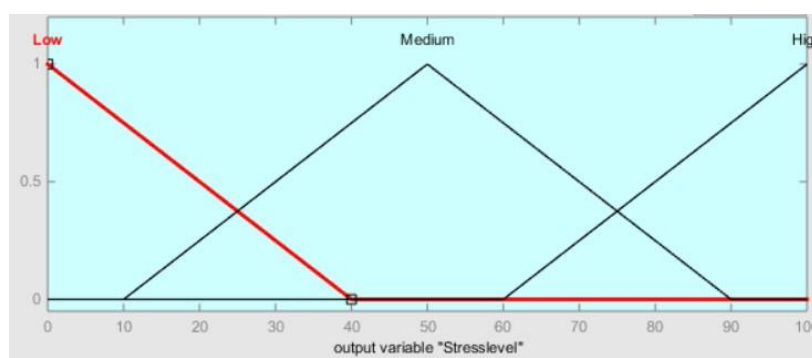
Fig 4: Membership functions and ranges for input (a) Skin Conductance level (b) Blinking of Eye (c) Voice frequency

After the FIS, Membership function editor is used where the ranges and the membership function are set. The ranges and membership functions for the input are shown in fig 4. The range for membership function skin conductance level is taken as 10-100 μ A with membership function high, medium and low as shown in figure 4(a). The range for membership function blinking of eye is taken as 15-30 blinks per minute with membership function slow, normal and fast as shown in figure 4(b). The range for the membership function voice frequency (Hz) is taken as 0-100% with membership function low, medium, and high in shown in figure 4(c). The overlapping between membership functions is taken because of the use of MAMDANI model for simulation.

The output membership function and ranges are shown in figure 5. The range for the output lies detection is taken as 0-1 with the membership function as no lie, possible to lie and true lie 5(A). The range for the second output parameter which is stress level is taken as 0-100% 5(B) in which 0-25 is resting state, 26-50 is low stress state, 51-75 is medium stress state, and 76-100 is high stress state.



5(A)



5(B)

Fig 5(A and B): Membership functions and ranges for output lie detection and stress level

The ranges of all the parameters are shown in the table below. The process of calculation is done through the rule viewer graph and last make the comparison between simulated and calculated values.-

Table 1: Input Parameters and their ranges

Input Parameters	Ranges
Skin Conductance	10 μ S-100 μ S
Blinking of Eye	15-30 blink per min
Voice Frequency	0-100%(Hz)

Table 2: output parameters and their ranges

Ouput Parameters	Ranges
Detection	0-1
Stress Level	0-100Pa

Based on these values a comparison is created which compare the minimum values for the calculated membership function values. The minimum value is the multiplied with the singleton value to calculate the value of the respective output. This is done by viewing the rule viewer graph. The rule viewer is a MATLAB based display of the fuzzy inference diagra shown at the below. Use the rule viewer to view the inference process for desire fuzzy system. We can adjust the input values and view the corresponding output of each fuzzy rule.

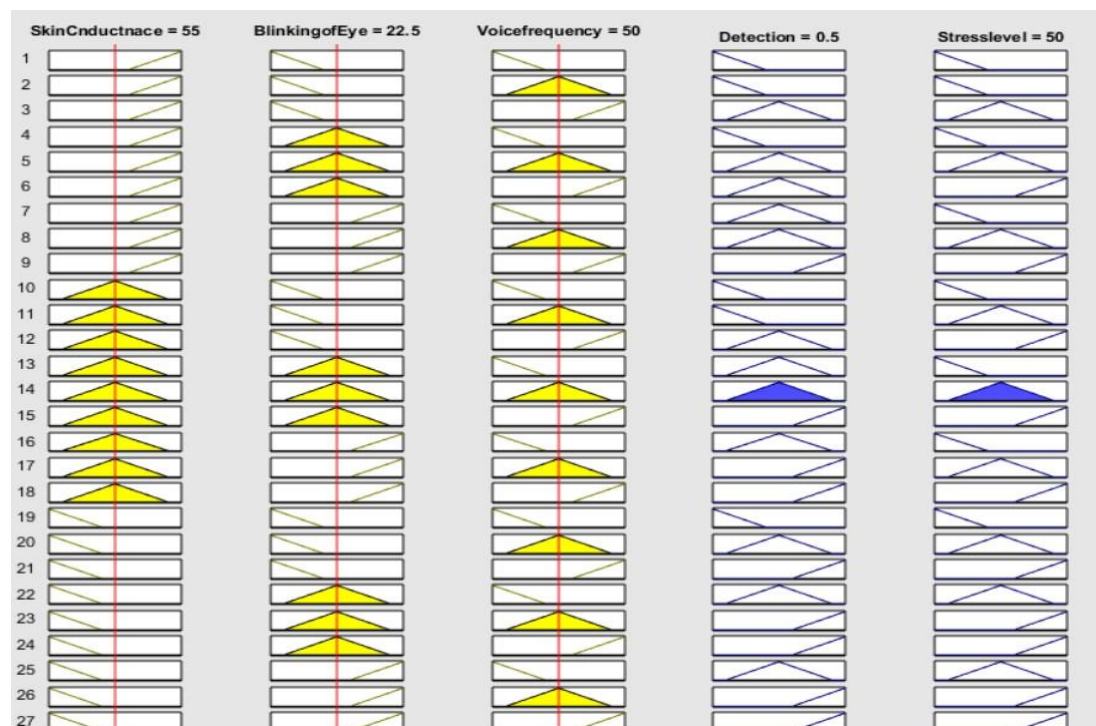


Fig 6: Rule viewer of the simulation work

Simulated value of output 1 i.e., detection from rule viewer = 0.35

Calculated value will be calculated from Mamdani formula:

$$P = [\Sigma (M_i \times S_i) / \Sigma M_i] * 100$$

$$P = 0.35\%$$

Simulated value of stress level from rule viewer graph = 36.1

Calculated value of stress level from Mamdani formula is:

$$P = [\Sigma (M_i \times S_i) / \Sigma M_i] * 100$$

$$P = 37.02\%$$

Result and Discussion

2-Dimension graphs for Detection:

For the three most important parameter to identify that a particular person he or she is telling a lie or not in the investigation process and also measuring their level of stress according to these inputs, fuzzy logic is implemented for these three inputs including skin conductance level, blinking of eye, and voice level. Based on the rules defined, the 2D graphs for the work are defined. The 2D graph between skin conductance and the detection of lie is shown in figure 7. The graph shows that greater the skin conductance level of a person the higher possibility that a person is telling a lie or conceals some information.

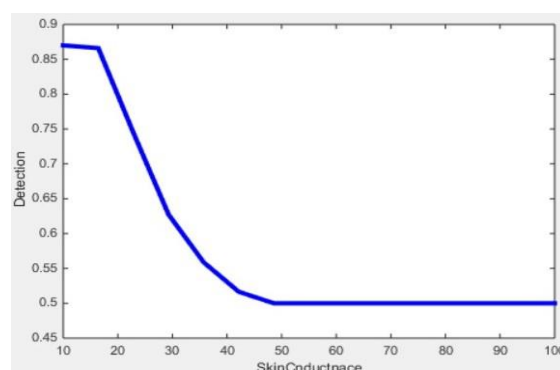


Fig 7: 2D graph of Skin Conductance Level with detection (true lie or no lie)

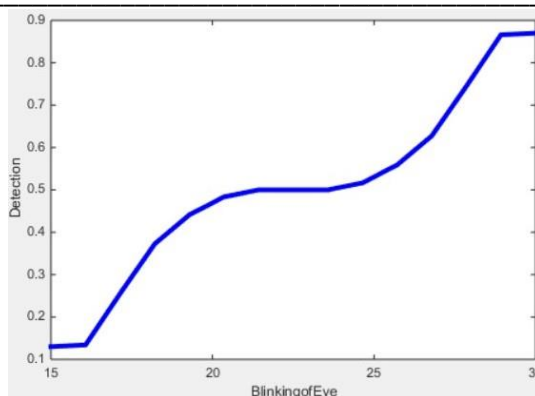


Fig 8: 2D graphs of Blinking of Eye with detection (true lie or no lie)

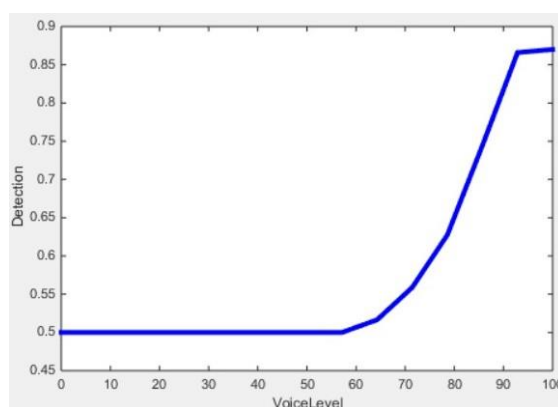


Fig 9: 2D graphs of voice frequency with detection (true lie or no lie)

It is clearly showing that when the voice frequency of person he or she is higher than the normal frequency range which is different for male, female, and children i.e., 100-300Hz indicates that a person is telling a lie.

3-Dimension Graphs for detection:

The 3D graphs between the input and output are shown in Figure 10 shows the 3D graphs between Skin Conductance and Blinking of Eye with detection (no lie or true lie). Figure 10 and 11 shows the 3D graphs between Skin Conductance and Voice Level with detection (no lie or true lie).

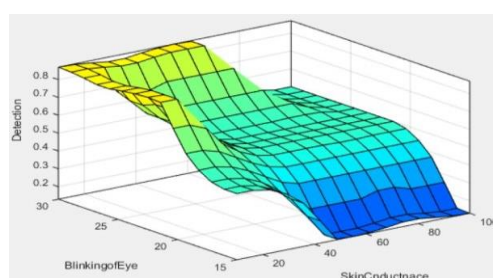


Fig 10: 3d graphs between skin conductance, blinking of eye with detection

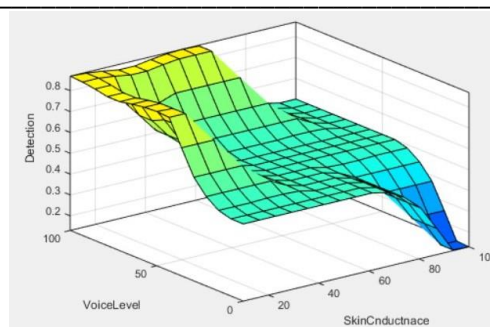


Fig 11: 3d graphs between skin conductance, voice level with detection

2-Dimension graphs for stress level:

Fuzzy logic is implemented for the three inputs—skin conductance level, eye blinking rate, and voice frequency—that are crucial for determining whether a specific person is lying or not by measuring the stress level of a particular person he or she during an investigation in relation to these inputs. The 2D graphs for the work are defined based on the rules specified. Figure 12 displays the 2D graph relating skin conductance to the detection of lies. The graph demonstrates that the likelihood that a person is lying or hiding information increases as a person's skin conductance level increases as the stress level of an individual increases as well as the increase in other input parameters.

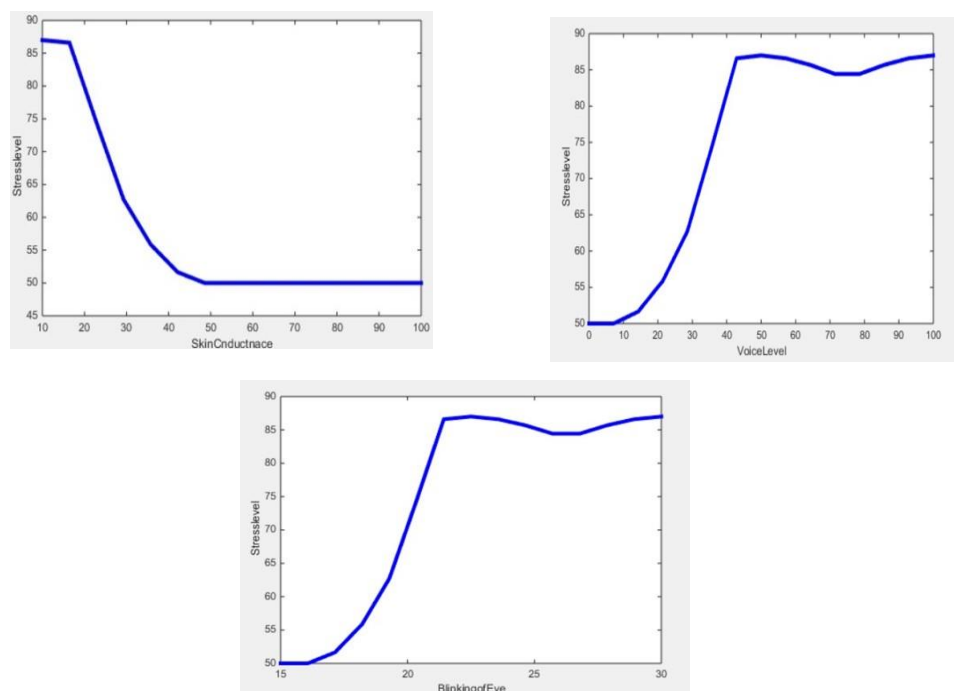


Fig 12: display the 2d graphs between all three parameters with stress level

3-Dimension Graphs for detection:

The 3D graphs between the input and output are shown. Figure 13 shows the 3D graphs between Skin Conductance and Blinking of Eye with stress level and also shows the 3D

graphs between Skin Conductance and Voice frequency with stress level to show the direct relation with detection. As the stress level increases with respect to the following parameters the detection shows that a person is suspect as a liar.

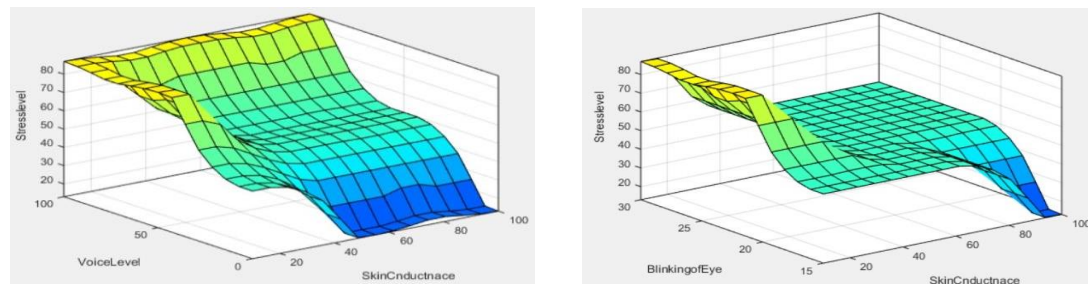


Fig 13: 3D graph between output stress level with input (a) Skin Conductance and Blinking of Eye (b) Skin Conductance and Voice frequency.

Comparison between simulated and calculated value of both outputs detection and stress level are shown in table 3 and 4 which gives the percentage error of less than 1(>1).

Table 3: Comparison between the calculated and simulated value of detection of lie

Output 1	Simulated value	Calculated value	Percentage Error
Detection (truth or lie)	0.35%	0.357%	0.007%

Table 4: Comparison between the calculated and simulated value of the stress level

Output 1	Simulated value	Calculated value	Percentage Error
Stress Level	36.1%	37.02%	0.92%

The error of less than 1% shows the accuracy of the work. The work shows that the higher the input parameters skin conductance, blinking of eye, and voice frequency, maximum accuracy to detection the person who tells a lie or conceal come information during the investigation process in any public and private institutions. This shows that it is required to improve and work in the process of interrogation i.e., dedicated environment, expert interviewer, and targeted questions, so it will easy to analyses these parameters that were discuss in this paper.

Comparison between current study with previous study

Table 5, gives the detailed comparison between all the previous studies with this research study regarding detection of lie using different techniques to achieve high accuracy level based on various parameters such as facial micro expressions, body languages, EEG spectrum speech analysis, skin analysis, eye pattern.

Table 5: Benchmark

References	Techniques	Parameters	Findings	Accuracy/ Efficiency
Monari. Merylin [20]	Machine learning	Facial Expressions	Increase in the cognitive burden makes easier to detect the liar	57%
Nuria, Rodriguez [21]	Deep learning	Facial Expressions	Annotated photos of various participants during a card game that rewards lying	63%
C.S Barathi [22]	Speeded up robust features approach	Facial Expression, speech analysis, body language	Analyzing the body cues that exhibits by a liar	82%
M. Nasrun [12]	Transform technique and counting of blinks	Dilated pupil, blinking rate	Lie will increase in blinking rate up to 8 times and pupils widen by 4 to 8%	84%

Ying Fang Lai [16]	Fuzzy reasoning approach	EEG (Brain signals)	Combination of fuzzy with brain waves measurement and create a porotype for the detection of lie	89%
<u>Kai Xin Beh</u> [23]	Spontaneous Micro expressions from videos	Facial land-marks	changes in the ratio of Euclidean distances between three facial landmarks—the left eyebrow, right eyebrow, and mouth, describe the liars	82.30%
G. Krishumurthy [24]	Deep learning	Videos, text, MEs	Recording all parameters makes it easy to detect the deception	96.14%
This work	Fuzzy Rule Based approach	Skin conductance, facial expression and voice level	High skin conductance, increase in blinking rate and high voice level shows the increase in stress level of a person is a clue that a person is a liar	Direct relation between these three input with stress level

Comparison between current study with previous study

Lie detector tests are crucial due to their numerous practical applications. They are practical instruments used to distinguish between sincerity and dishonest behavior in a range of sectors. Crime investigation units, national security organizations, business, and industry are a few of the key organized industries that utilize lie detection testing.

Crime and Investigation

Criminal investigations are one of the main contexts when polygraph tests are utilized to uncover lies. They offer a useful and simple technique for government agencies and the legal system to interrogate criminal suspects. Security agencies are a key additional environment for polygraph examinations. With the help of polygraph tests, security personnel can spot potential terrorists and other troublemakers who might hide their identities [6].

Industrial and Business Sector

In industry or business, lie detector tests—typically polygraph tests—have a second important purpose. They significantly contribute to boosting organizational effectiveness. Employing employees with the right training and experience and promoting employee integrity at work are key components of effective and successful organizations. On the other hand, candidates for employment have the option of lying on their applications during the hiring process. They can erroneously claim to have the education and experience required to land a job.

Insurance Industries

Lie detection has become a crucial component of any organization, particularly in the insurance industry, due to the prevalence of frauds, whistle-blowers, phishing, corporate or product sabotage, and many other issues. Several advantages of lie detection in the insurance sector are listed below [25].

- ⊗ It offers a more peaceful means of resolving conflicts and uncovering fraud.
- ⊗ In the event of a dispute or disagreement, it is helpful to confirm the legitimacy of an insurance client. In fact, the ideal approach to resolve these kinds of disputes between the two sides would be a polygraph test.

Challenges in the detection of lie

Although polygraph tests have some practical uses, there are a number of difficulties. Lie detection tests are more commonly challenged on the grounds of accuracy, relevance, the suitability of professional training to catch a liar, and ethical concerns [26].

Accuracy

The inaccuracy of these devices directly contributes to incorrect categorization of test subjects. Significant classification errors like "false positive" (declaring innocent crime suspects to be dishonest) and "false negative" (declaring dishonest crime suspects to be innocent) reveal that these instruments are incorrect. It is evident that classification mistakes are the largest challenges for lie detection tests and compromise their core objectives.

Ethical Issues

Serious ethical problems are usually caused by this exam. One of the main racial concerns associated with the use of polygraphs is the threat to test individuals' personal liberties. The polygraph tests blatantly violate the civil rights and personal privacy of individuals undergoing them because a variety of criminal suspects or examinees are obliged to participate in them. The usage of the testing in industry raises similar privacy infringement concerns. In the event of industrial thefts, numerous employees would be required to submit to polygraph tests, which would seriously jeopardize their right to privacy.

Relevance

The creation of a deception scenario that is applicable to what professionals encounter during the interrogation process presents another obstacle for study in lie detection training.

Conclusion

In conclusion, the combination of stress level-based skin analysis, voice frequency, and facial expression for lie detection and fuzzy analysis has great promise for a variety of applications, including forensic investigations, security screening, and psychological research. To improve our understanding of human behavior and deception detection, this ground-breaking method makes

Additionally, the way someone is feeling can be inferred from their facial expressions, which can either-confirm or contradict other signals. This technique aims to provide a more thorough and accurate assessment of a person's emotional state and potential deceit by integrating stress level-based skin analysis and facial expression analysis. Stress-related physiological changes in the skin, such as variations in conductivity and electrical resistance, can be a sign of elevated emotions and the mental strain involved with lying. So, this analysis provides a way to predict that a person is lying when all three parameters i.e., Skin conductance, voice frequency, and blinking of eye increases which effect on stress level of a body.

Author's Contribution: H.A.R, ,Q, Conceived the idea; M.Q.S, and H.A.R., Designed the simulated work or acquisition of data; H.A.R, F.Q, Executed simulated work, data analysis or analysis and interpretation of data and wrote the basic draft; H.A.R, M.Q.S, & F.Q., Did the language and grammatical edits or Critical revision

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