

DOI: 10.25696/ELSYS.VC1.EN.5

RESEARCH OF VIDEO POLYGRAPH FOR LIE DETECTION WITH STATEMENT ANALYSIS BY VIBRAIMAGE TECHNOLOGY

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Abstract: *Human has more complicate and skilled ability and so he may cheat not only myself but also other. It is not easy to cheat unconscious things like sweat, eyes, or voice, but if someone cheat own self, he can cheat every of that. Lie is one of the way to spread our gene and our instinct make a lie. Every living organism even bacteria or virus use similar trick to survive. In human body, there are more complicate and profound mechanism for lying like breathe, sweat, eyes, face or voice. We can control some of that and make a fake, but it can't be perfect. Human also called 'Homo Fallax' cause we have a language and skill to lie with it. In present, we can detect lie with the traditional polygraph, but it has a few of weakness.*

Polygraphs are being used as the lie detectors in the United States, Canada, Russia and South Korea. and many other countries. However, since the conditions for using polygraphs and technique requiring skills are required, it is difficult to apply in a wide range and has not been distributed largely. In this paper, we describe the results of researching the possibility of judging the probability of lie level using only video and voice recording, which is one of the non-contact method using Vibraimage technology for resolve it. Hereafter, we will call it as "Video Polygraph" comparing to the traditional contact method in lie detection system. Especially, this paper is to focus on analyzing the lie probability for the hierarchical statement analysis based on Vibraimage technology.

Keywords: *Statement investigation, video polygraph, vibraimage, vestibulo-emotion reflex.*

1. Introduction

Lie detection methods based on the video image may be more appropriate to say that they are so innovative and evolutionary under some questionable matters, while polygraphing methods are commonly used in lie detection methods. However, owing to Vibraimage technique that measures and analyzes parameters resulted from the micromovement of head/face due to the reaction of vestibular system according to the emotional variation, the method of lie detection using the real video iamge also became closer to reality.

In addition to the ever-growing science and technology, the need for changes in new technologies that are easier to use in the environment of use and more reliable is no exception to the scientific investigations. The lie detector, which started in 1921 with the development of John Larson, evolved with a long history, but there is still no significant change in the controversy over the infringement of human rights and the problem and limit of use from the examiner's point of view until today, nearly a hundred years later [1, 2, 3].

In particular, there is no criminal investigation technique and skill that probabilistically display the judgment of the statement on the current statement analysis. Also, there is no technology or product to judge and determine the authenticity of statements by the non-contact type of video image based on Vibraimage [4, 5, 6]. Since the existing written statement and counseling analysis method depends on psychological crime analysis technique by the investigation experience, there is a part which is difficult to judge without expert insight or long experience [3]. The crime analysis by the subjective judgment is biased, which hinders the advancement and efficiency of the scientific crime investigation.

Russian neurophysiologist born in 1913 year, Alexandro Romanovich Luria worked at the Moscow Institute of Psychology, earned a reputation for research on the correlation between thought processes and response times [7, 8]. He devised the so-called "combined motor method" that describes how to analyze human thought processes. It became the principle of the first polygraph [7,8]. The content of this study was first published in the United States in 1932, and first published in Russia in 2002.

The German psychologist Munsterburg laid the foundations for today's lie detection theory and published the validity of the actually judicial application by studying the effects of blood pressure, breathing, and skin current responses on emotions. In 1921, at the Berkerly Police Department in California, USA, John Larson imported and started to operate the scientific lie detection technique in police activities, who was stimulated by the performance of Marston. The traditional Polygraph examination was variously applied by Utah, Backster, CIT (Guilty Knowledge Test) etc. [1, 2, 3].

However, since the conditions for using the current Polygraphs and technique requiring skills are required, it is difficult to apply in a wide range and has not been distributed largely. In this paper, we describe the results of researching the possibility of judging the probability of lie level using only video and voice recording, which is one of the non-contact method using Vibraimage technology for resolving it.

2. Analysis method of video image by Vibraimage technology

The statement analysis process by Vibraimage technology requires the recorded video image file captured through a webcam and it is analyzed by VI parameters [1, 2, 3, 6, 7, 8]. However, the video container should be AVI format, and the encoding method should be recorded in the form of Uncompressed RGB as per Vibraimage operation guide.

Image analysis requires a Windows-based PC and performance requires a CPU that supports two or more threads of 2,0 GHz or more, and 2 GB or more memory. The PC used in the analysis is a specification that meets this specification

2.1. Extraction of the highly co-related parameters

It is necessary to extract the most correlated variable parameters for authenticity judgment using Vibraimage technology. Vibraimage 10 version was used under

the process of software licensing. The analysis of the video images obtained according to the specified question procedures creates the Vibraimage parameters. Among the parameters, two majorly co-related parameters were extracted and then, its new parameter was named as X1 parameter, which were deeply related to concentration and exciting respectively [9].

2.2. Data analysis

The analysis is conducted using the acquired X1 data. First, it makes sure that the maximum value of X1 data exceeds or not the specific threshold. The criterion of the threshold is the result of statistically calculating the threshold value with the highest concordant rate compared with the polygraph testing result among the values near the center value when the video image samples are classified and the whole data is compared. Then, the data is separated into the question procedures, the ST (State Tracking) section, the AT (Adaptive Tracking) section, and the remaining section. The questions are classified as the five question sections. The ST question section and the AT question section are sections for obtaining the psychophysiological data of the testee independently without interchange with the investigator, and are also used for pre and post comparison. Therefore, it is the section that is influenced least by the tone and atmosphere of the investigators who may be different. After separating the data, we compared the average values of the ST section and AR section. It is a secondary indicator of authenticity based on the difference of the mean value. These two indicators were used to determine the degree of authenticity [9].

3. Possibility to develop Video Polygraph application by the hierarchical statement analysis

3.1. Video Polygraph overview

The conventionally contacting Polygraph test says, In general, when people lie, emotions such as anxiety, tension, and fear about the revealing of the lie are created, these emotional changes (emotional stimulus) are bound to cause a variety of physiological changes by the action of the nervous system and hormones [1, 2, 3]. Among these many physiological changes, Polygraph was proven by the research and the long operation, which uses the scientifically measurable methods, respiratory activity (respiratoryactivity), skin current activity (electrodermalactivity), and cardiovascular activity. It is recorded by inspection procedure, technique, equipment and etc., and the judgement is analyzed by Polygraph examiner to determine the authenticity of the statement. The non-contact image-based Vibraimage technology is to use an algorithm that visualizes the micro-movement of the head by the brain vestibular system (equilibrium sensory) and then, it analyzes and evaluates human psychological and emotional states to determine the authenticity of the statement [1, 2, 3, 9].

3.2. Major features in Vibraimage technology for Video Polygraph

There are three major features in Vibraimage technology.

First, VER concept, known as vestibular-reflex, is that the reflexes of emotional expressions express emotions in humans and animals [4, 5, 6, 10]. All external responses to brain activity can be characterized by muscle movement [4, 5, 6, 10]. The vestibular system that contributes to human balance and spatial position is a sensory system that provides movement and equilibrium. It is anatomically known that vertical human head positions are controlled by the vestibular system through the head-neck [11, 12, 13, 14].

Second, VER concept that requires the vestibular system to work all the time to maintain their body balance and to cooperate with the vertical head muscle coordination is done constantly and, according to the process is followed by the continuous reflection (reflex) [4, 5, 6, 10].

Third, the concept of symmetry uses the cooperation of vertical head muscle movements to control energy because the natural head movements are not regular in the vibrational movement according to a particular pattern. Therefore, it is possible to perform a various analysis depending on the degree of movement, with the left and right movements naturally based on the vertical center point [4, 5, 6, 10].

The statement analysis method using the video image-based on Vibraimage technology is based on the conditioned testee's mood background. On the contrary that the existing statement analysis is based on the writing statement, Video Polygraph is a method of analyzing the authenticity level of the testee by detecting and analyzing psychophysiological signals during the structured or semi-structured interview form under the verbal statement video image of the testee and examiner.

3.3. Question structure of the hierarchical statement analysis

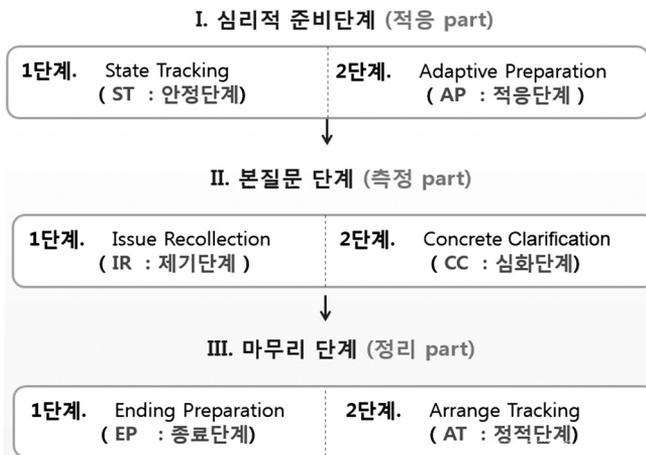


Fig. 1. Flow of Questions

During the entire three-step investigation processes, the I and III stages proceed with the concept of padding (buffering) for the accurate measurement of the II stage.

The psychological preparation stage at the I stage is an adaptation concept that prepares for programming physiologically the II stage in which the main questions are conducted.

I-1. State Tracking (described as ST) measures the stable state without any stimulus by allowing the interviewer (testee) to take a psychophysiological test for one minute for the initial baseline setting.

I-2. Adaptive Preparation (described as AP) is a step toward asking the warm-up question before the main question, asking questions about the safe, general, and personal topics that do not involve the rapport forming and emotional elements. It verifies the episodic memory that is coupled with the experience associated with time and space.

II-1. (Main question stage). Issue Collection (described as IR) recalls the key theme and process of the event and allows the episodic memory to be freely stated within about three minutes.

II-2. (Main question stage). Concrete Clarification (described as CC) is a concept of the deepened questions about contents stated at IR stage, consisting of at least two additional questions for the realization of the poor statements and the clarification of key points. CC stage can comprise the questions that are requested to explain the contradictions of evidences and the reasons why you are suspected (the clear facts > the signed facts > the allusive facts), the detailed demand for concealment, omission, or poor statements, the demand of the active explanation about why you are innocent, to change your viewpoint in cognitive interviews, or to change your order.

However, in this process, the investigator should ask as open as possible questions, excluding the induction questions or pressure questions, and ask them to make the rich statements voluntarily rather than the short answers.

III-1. (Finalization stage). Ending Preparation (described as EP) is a physiological preparation process that concludes the examination and is a formal and ritual question for understanding the additional information and expanding the self-defense opportunities of the testee.

III-2. (Arrange tracking stage). Arrangement Tracking (described as A.T.) is a step in tracking the latter stabilizer, which is compared to the previous ST by another psychophysiological state without a statement for a minute.

3.4. Key parameter extraction for judging the probability of lie or truth

When the measurement is started by bringing the captured video image to VIBRASYSTEM, the Vibraimage parameters are generated. Among parameters, 10 emotional parameters are supported and 8 highly co-related parameters can be extracted from all Vibraimage parameters. Finally, the key parameters are selected and then three ones for judging the probability of lie are generated as the key functional parameters by combination, which is named and called as Y1, Y2, Y3. VIBRASYSTEM extracts the unique algorithm using those three parameters by

giving some different weight factors. Its formula is composed as below equation (Table 1).

The first judgement basis for the lie probability is depending on Y level. Video Polygraph by VIBRASYSTEM will provide four grades of lie level (A, B, C, D grade) according to lie probability (%). "A" grade in lie level means the highest lie probability (in case that lie probability is over 85%). "B" grade is over 75~85% in lie probability. This definition is based on VIBRASYSTEM's own judgement. Here, the criminal investigator gets the meaningful judgement from "B" grade for DI (Lie judgement).

Table 1

Equation for statement analysis in Video Polygraph

$$Y = aY1 + bY2 + cY3$$

Here, a : 1st weight factor,

b : 2nd weight factor

c : 3rd weight factor

Y1, Y2, Y3 : Key parameter extracted by combination of some parameters

Additionally, it begins with the clinical trial in which there is a difference between the first stage (ST) and the last stage (AT) in the background of a moody state for a true testee and a false testee. In general, the true statement maintains a consistent attitude, but the false statement usually escapes a consistent pattern. The ST stage and the AT stage are stages for obtaining the psych-physiological data of the testee independently without interchange with the examiner, and are also used for comparisons between before you start the examination and after you finish the statements. Therefore, it is also the stage that is at least influenced by the voice tone and atmosphere of examiners who may be different. After separating the data, the average values of the ST stage and AT stage were compared. It is a secondary indicator to judge authenticity or probability of lie based on the difference in average value. This result of analysis in the calculating the change rate between ST and AT influences very essentially to determine whether lie or truth or inconclusion. Especially, the calculation result helps to classify the inconclusive judgement due to the very vague situations when examine the investigation.

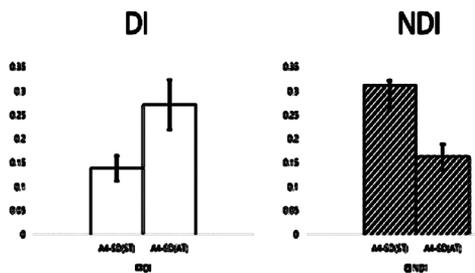


Fig. 2. Sample of data change authenticity between DI and NDI

As shown on Figure 2, about the differences between DI and NDI in ST and AT stage, the change of DI increases at least more than 10 (change rate). The change of DI is low at ST (first silence stage) and then increases at AT (last silence stage). On the other hand, NDI shows a relatively high change in ST and then decreases to less than 10 (change rate) in AT stage.

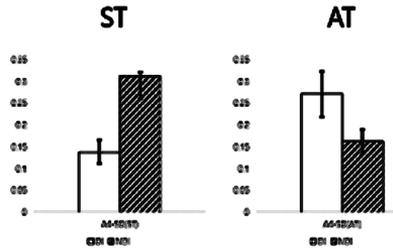


Fig. 3. Sample of data change authenticity between ST and AT

In comparing the change of standard deviation (SD) as shown on Figure 3, according to the final judgement between DI and NDI, when its change rate is more than 10, it was resulted in DI. On the contrary, it was resulted in NDI while its change rate is less than 10.

3.5. Analysis result in statement examination

The behavior science analysis team in Seoul Metropolitan Police Agency obtained 85 real cases using Vibraimage technology as the video image-based on the hierarchical statement analysis, which was calculated by Video Polygraph application.

The total number of Video Polygraph Test Experiment Research for the hierarchical statement analysis using video image-based on Vibraimage is 85 cases. The 8 inconclusive cases were excepted to count the concordant rate, because the bad video image file due to the bad conditions and atmosphere should be excluded to this testing experiment research. Of the total 77 cases, 62 cases were consistent and 15 cases were inconsistent, showing the concordant rate of 80,5% finally.

Table 2

Distribution rate by criminal case

Item	Non-Concordance	Concordance	Except	Sub Total
Robber		2		2
Threat	2	1		3
Defamation		1		1
Fire		2		2
Malpractice		1		1
Violent death		1		1

Table 2 (*the end*)

Item	Non-Concordance	Concordance	Except	Sub Total
Fraud	1	1		2
Murder	2	4	1	7
Attempted murder			1	1
Sex violence	3	24	2	29
False witness	1	1		2
Property damage		5	2	6
Robber	3	11		16
Violence	3	6	3	12
Total	15	62	8	85

4. Conclusion

The existing polygraph tests are in direct contact with the body of the testee and are conducted and operated for a long time. This has an unreliable effect on the test results, such as human rights and distortions, for the testees. The research is under development to supplement this and to adjust the inspection environment that can be accessed conveniently and friendly. This is a real hierarchical statement analysis solution based on Vibraimage technology. We conducted the video image-based hierarchical statement analysis and observed the possibility of testing used in the standard procedure of basic polygraph inspection in Korean National Police.

The followings are to introduce the first technology and application differentiated in Korea's technology of Video Polygraph development research process.

First, we developed and used the structured and semi-structured the video image based statement analysis. It takes about 10 minutes to be clarified by three stages. The first stage is a Physiological Preparation Stage (Stable stage and Adaptive Preparation), the second stage is a Main Question stage (measurement stage), and the third stage is a Finalization stage (Static stage). The questions are asked about the conditioned testees that can recall the episodic memory.

Second, the meaningful indicators in the statement examination are found at Y1 (related to excitement, concentration), Y2 (related to Frame difference accumulated in N consecutive frames) and Y3 (related to level of lie) and the change rate between ST and AT. A true person is psychologically consistent to stability from beginning to end, while a false person is not consistent and ends with anxiety.

Third, the stimulation test can be also be performed in video image-based hierarchical statement analysis, such as basic polygraph tests. The video image-based hierarchical statement analysis can read the statement status through the primary and secondary tests. The stimulation tests need to be researched in the future continuously.

It is expected that it will play a role in understanding the video image-based hierarchical statement analysis technology as well as Vibraimage technology for both the general public and the testee.

As mentioned above, we have discovered and studied to research many real cases by applying VIBRASYSTEM to polygraph testing, but we have made some suggestions to improve the reliability, feasibility and efficiency

First, we need to keep studying the additional researches to improve the reliability and feasibility. The concordant rate is different from that of the existing polygraph by the criminal case, and we should keep working to increase the concordant rate comparing to polygraph test.

Second, the manual measurement of the average value of the silent answer stage was difficult, and its value at the stable random point was determined during the silent answer stage, which could result in an error or tolerance of the measurement value. The average value of one minute of ST stage (stable stage) and AT (adaptive phase) is expected to be accurate, so the statistical processing through the computerized program will be useful and valuable from the testing. Third, the video image-based hierarchical statement analysis of Vibraimage technology has been validated and reliable in the research process. Many clinical data with the real criminal cases must be produced to increase the reliability based on Vibraimage technology.

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