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Real-time microreaction recognition system

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ABSTRACT

This study constructed a real-time microreaction recognition system that can give real-time assistance to investigators. Test results indicated that the number of frames per second (30 or 190); angle of the camera, namely the front view of the interviewee or left (+45°) or right (−45°) view; and image resolution (480 or 680 p) did not have major effects on the system's recognition ability. However, when the camera was placed at a distance of 300 cm, recognition did not always succeed. Value changes were larger when the camera was placed at an elevation 45° than when it was placed directly in front of the person being interrogated. Within a specific distance, the recognition results of the proposed real-time microreaction recognition system concurred with the six reaction case videos. In practice, only the distance and height of the camera must be adjusted in the real-time microreaction recognition system.

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1. INTRODUCTION

The improvement of technology and popularization of big data analysis have facilitated the prevalence of video surveillance systems constructed with artificial intelligence (AI) deep learning [1]–[6], [7]–[10]. Because deep-learning methods require only a small number of samples and can complete training and validation within a short period of time, they are used in the recognition of human activities, facial expressions, and voices. In terms of their extended applications, deep-learning methods are used in research, crime prevention and alerts, medical assistance, accident alerts, and emotion recognition [11]–[17].

The main responsibility of staff at the Ministry of Justice Investigation Bureau is the investigation of major criminal cases. Inquiry is one of the important means of investigation, as is carefully listening to whether a person's statement is in agreement with the evidence. By observing the body movements of a person being interrogated, Ministry of Justice Investigation Bureau staff can evaluate the reliability of the person's statement, infer more clues, and obtain evidence. Because of the recent coronavirus disease (COVID-19) pandemic, the identification of microexpressions through use of a facial action unit (AU) has become much more difficult (or failed completely) because people being interrogated now wear a mask.

Head posture and gaze direction also play crucial roles in emotional and social signals and expression and can be used to evaluate attention, social skills, mental health, and emotional intensity [18]. People's microexpressions and body movements after they have been stimulated are clues to what is in their mind [19]. When trying to hide a certain emotion, people tend to exhibit one of eight microreactions (i.e., the freeze reaction, territory reaction, look-up reaction, combat reaction, victory reaction, escape reaction, comfort reaction, and respiratory reaction).

In this study, two microexpressions, namely head movement and line of sight [20], [21], were used in combination with speech to recognize and analyze six microreactions exhibited by people being

interrogated. The self-designed real-time microreaction recognition system was employed to provide investigators with real-time analysis results, helping them determine whether a person being interrogated was exhibiting contradictory reactions. By doing so, the investigators could discover hidden emotions and adjust the strategy and direction of the interrogation in a timely manner, thereby improving the interrogation's efficiency.

The remaining sections of this study are as: section 2 presents the methods, including how data were collected and how useful information was extracted for analysis. Section 3 presents the results and discussion. Finally, section 4 summarizes the study conclusion.

2. METHOD

Image recognition was previously limited to manual data processing and relatively slow machine learning. At present, improved hardware and AI-based deep learning can rapidly process big data to ensure high efficiency of interactive learning. Scholars have devoted themselves to optimization of single software in image recognition research [22], [23]. So far, much open-source software, which can be connected and applied in response to different needs by using simple equipment, has been developed.

Previously, the facial action coding system (FACS) was used to interpret six human emotions through microexpressions [14], [15]. In this study, a multimodal combination was used to recognize these six human microreactions. The combination was expected to result in high recognition accuracy [24]. In terms of equipment, the user needs only a camera, microphone, and computer, all of which are already available in interrogation rooms, and must simply install the self-designed simple version of the real-time microreaction recognition system. The equipment enables investigators to discover potential contradictory emotional reactions of a person being interrogated on site, adjust their strategy of interrogation, and evaluate the direction of judgment and interrogation.

The proposed real-time microreaction recognition system combines data on head movement, line of sight, and volume difference; these data are recognized using OpenFace and OpenSmile to identify six reactions as shown in Figure 1. In this study, data were collected and compiled in the system through an application programming interface, and a database was established. OpenFace and OpenSmile have the advantages of real-time recognition and modularity, which enables connection.

- OpenFace: facial recognition is the simplest method for recognizing human emotions. In addition to facial recognition/marking and a facial AU, this software can identify head posture and line of sight. A simple information transmission system can be applied and integrated with other equipment [18], [22], [25], [26].
- OpenSmile: this open-source software was developed by the Technical University of Munich in 2008. It can analyze speech and music in real time. Its capacity for expansion, which is simple and diverse, enables the software to be applied in academic research on emotion recognition and in the medical field [27]–[29].

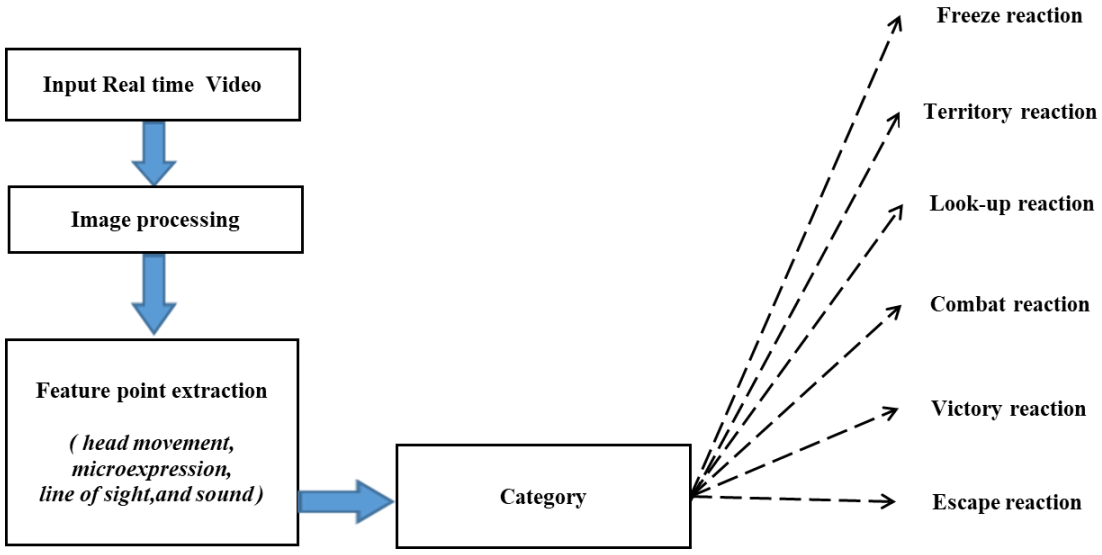


Figure 1. System flowchart

In order to obtain investigation-related information during interrogation, the interrogator must stimulate the interrogated in a timely manner, so as to find clues from the interrogated's emotions. The process of using the Bureau's real-time micro-reaction recognition system by the interrogators of the Investigation Bureau of this project is as shown in Figure 2:

- The interrogator appropriately stimulates the person being interrogated by asking questions or presenting evidence.
- The person being interrogated exhibits micromovements to hide their emotions.
- Because the performance of the person being interrogated is likely to have considerable consequences for them (i.e., it is a high-stakes situation), the authenticity of the micromovement is of great referential value.
- Technology assists with interpretation of the micromovements, enabling investigators to make an objective judgment on the basis of evidence.
- Upon discovering a contradictory statement, the interrogator can further stimulate the person being interrogated by asking questions or presenting evidence and then repeat the procedure.

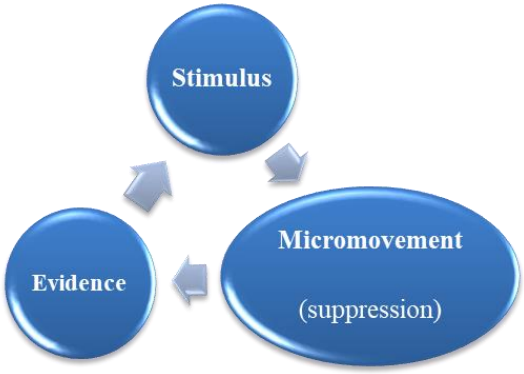


Figure 2. Interrogation process

3. RESULTS AND DISCUSSION

To obtain accurate recognition results in practice, this study employed various camera settings in its experiment: different frames per second (FPS; 30 or 190 FPS), angle [view from the front, left (+45°), or right (−45°)], elevation of camera (front or 45°), distance (30, 100, 200, or 300 cm), and resolution (480 or 680 p). Figure 3 shows the six reactions identified by the real-time microreaction recognition system; the intensity of the obtained reaction is shown on the left.

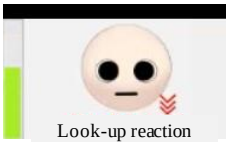
Reaction	Image	Reaction	Image
Freeze reaction		Combat reaction	
Territory reaction		Victory reaction	
Look-up reaction		Escape reaction	

Figure 3. Images of the reactions identified by the real-time microreaction recognition system

Different FPS tests freeze reaction as shown in Figure 4, territory reaction as shown in Figure 5, look-up reaction as shown in Figure 6 and combat reaction as shown in Figure 7. The results show that there is no significant difference between 30 and 190 FPS recognition. Different angles test freeze reaction as shown in Figure 8, territory reaction as shown in Figure 9, look-up reaction as shown in Figure 10 and combat reaction as shown in Figure 11. The results showed that there was no significant difference in the identification of three angles [front, left (+45°), and right (−45°)], but the GAZE left-right value was slightly higher at +45° and (−45°) than for the front setting. Different heights test freeze reaction as shown in Figure 12, territory reaction as shown in Figure 13, look-up reaction as shown in Figure 14 and combat reaction as shown in Figure 15. The results show that the GAZE Up/Down value increases significantly when the height is 45°.

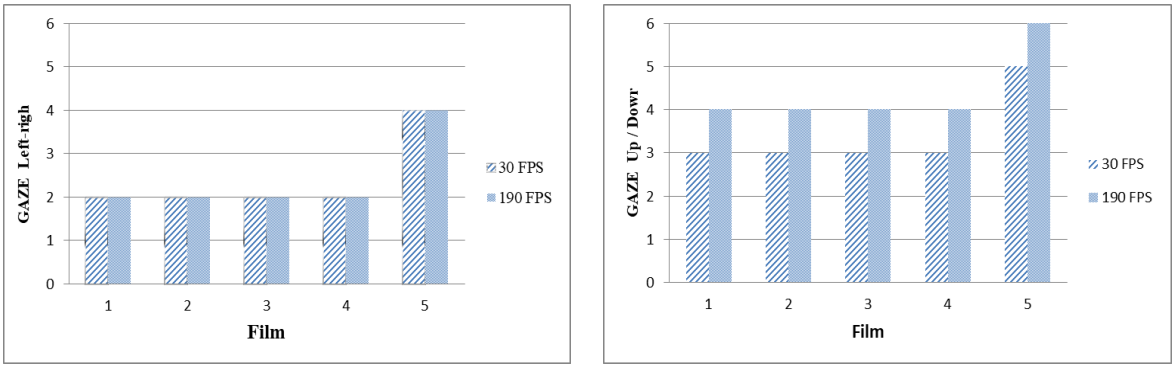


Figure 4. Freeze reaction (FPS)

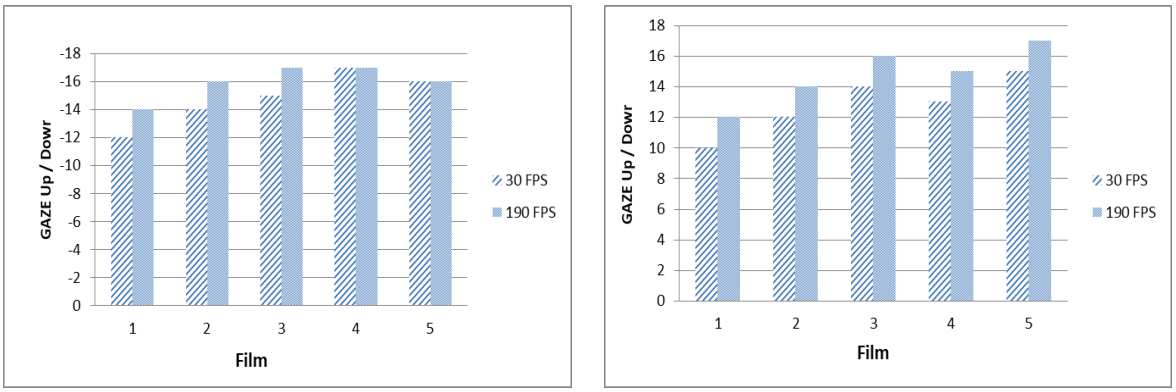
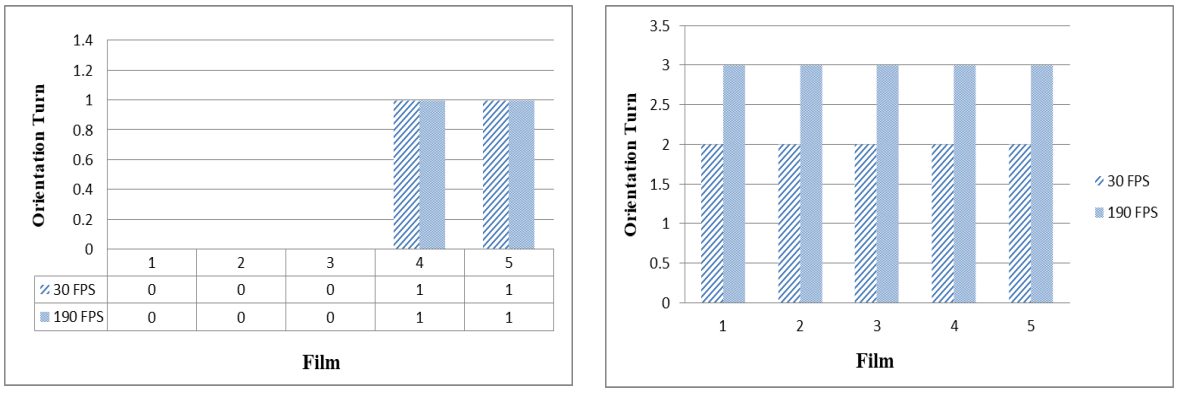


Figure 5. Territory reaction (FPS)

Figure 6. Look-up reaction (FPS)



	1	2	3	4	5
30 FPS	0	0	0	1	1
190 FPS	0	0	0	1	1

Figure 7. Combat reaction (FPS)

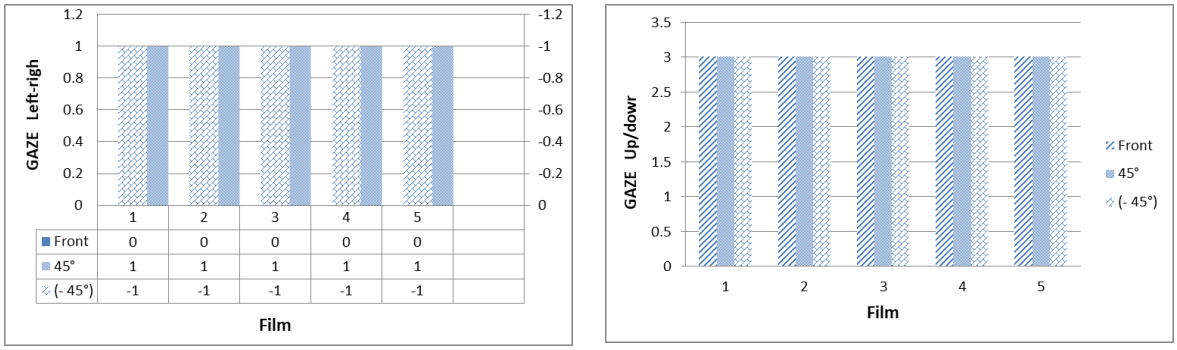


Figure 8. Freeze reaction (angles)

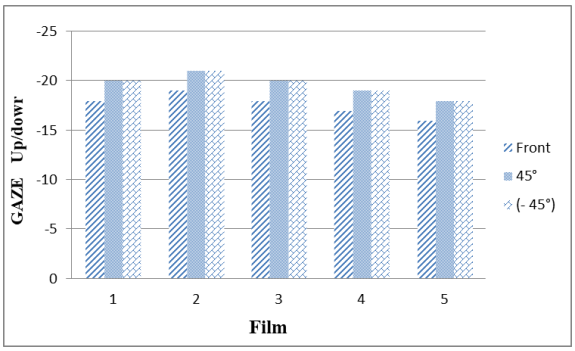


Figure 9. Freeze reaction (angles)

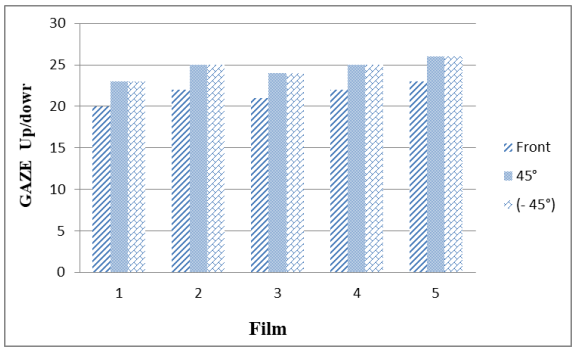
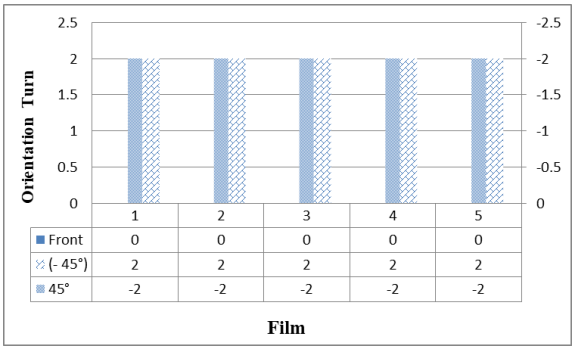


Figure 10. Look-up reaction (angles)



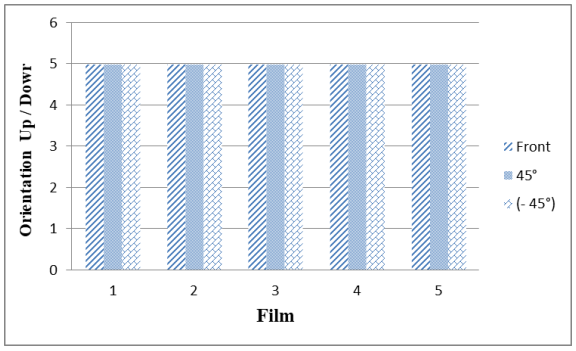
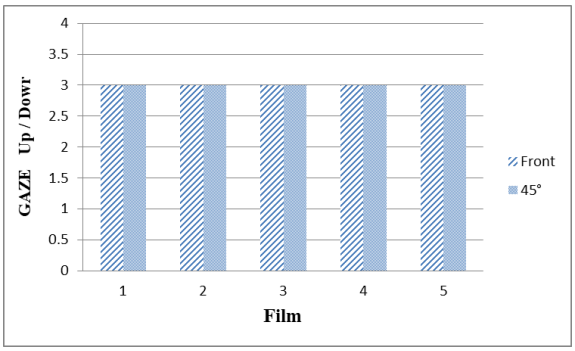


Figure 11. Combat reaction (angles)



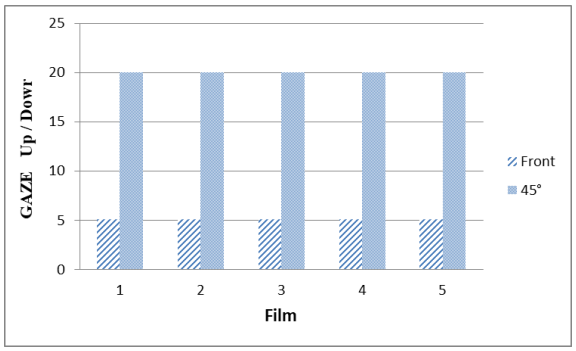


Figure 12. Freeze reaction (heights)

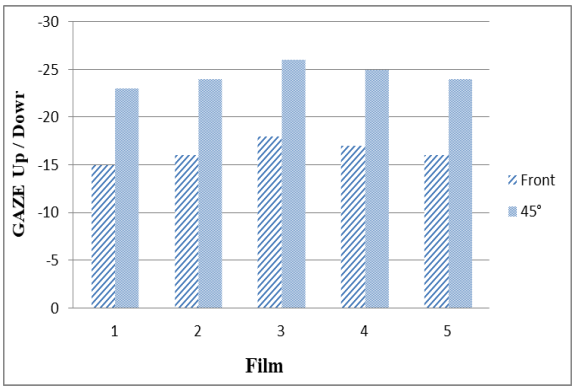


Figure 13. Territory ction (heights)

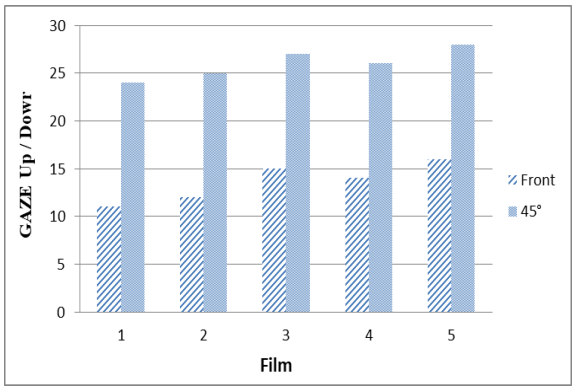
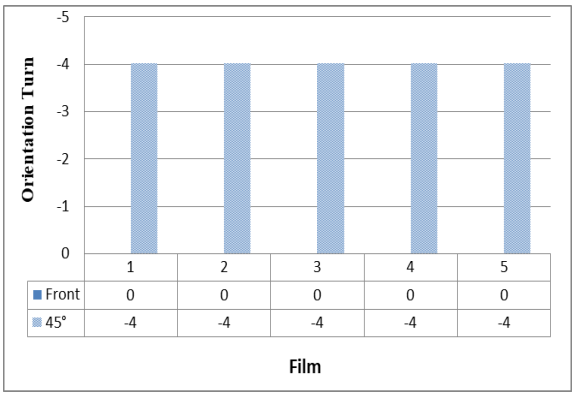


Figure 14. Look-up reaction (heights)



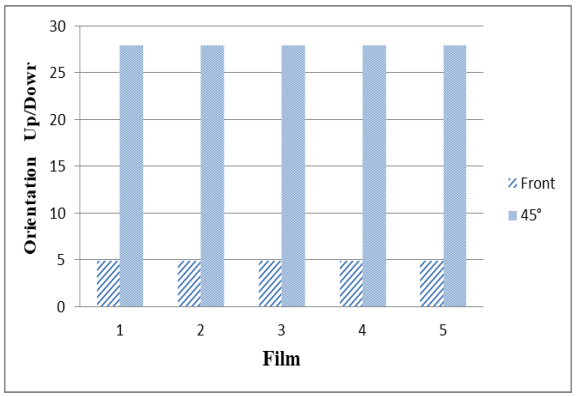
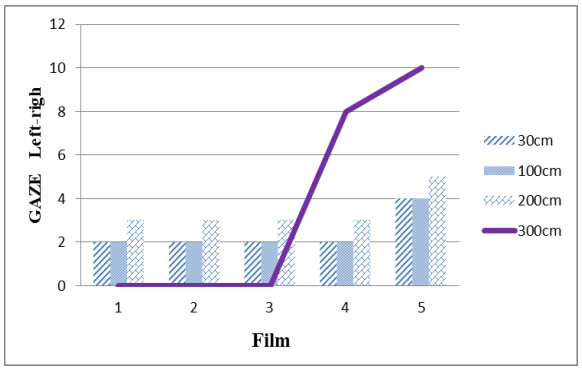


Figure 15. Combat reaction (heights)

Different distances test freeze reaction as shown in Figure 16, territory reaction as shown in Figure 17, look-up reaction as shown in Figure 18, combat reaction as shown in Figure 19, victory reaction as shown in Figure 20 and escape reaction as shown in Figure 21. The results of the first four responses show that when the distance is 300 cm, the value is displayed as 0 because sometimes it cannot be recognized, resulting in no recognition. All other states showed consistent results. Victory reaction and escape reaction use OpenSmile system identification, set the value difference between F0final_sma and the previous second to be between 30~140. Different resolutions test freeze reaction as shown in Figure 22, territory reaction as shown in Figure 23, look-up reaction as shown in Figure 24, combat reaction as shown in Figure 25, victory reaction as shown in Figure 20 and escape reaction in Figure 21, the results show that the two there is no significant difference in the recognition of different resolutions (480 and 600 p).



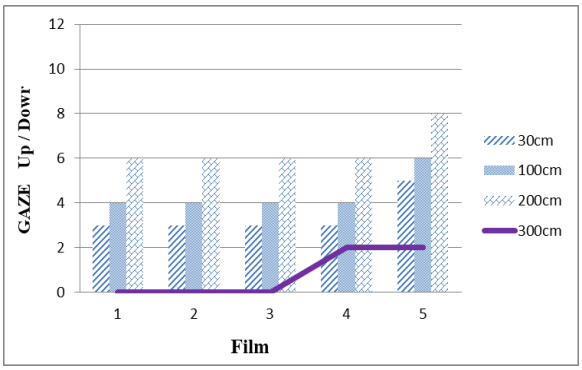


Figure 16. Freeze reaction (distances)

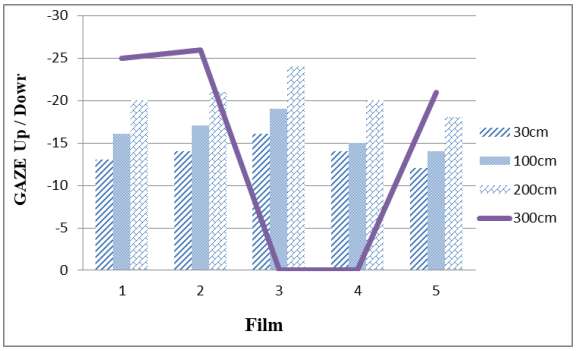


Figure 17. Territory reaction (distances)

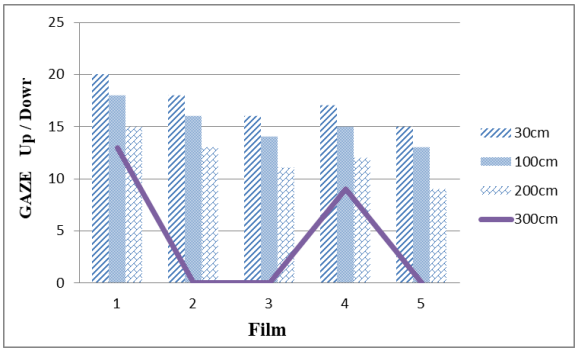
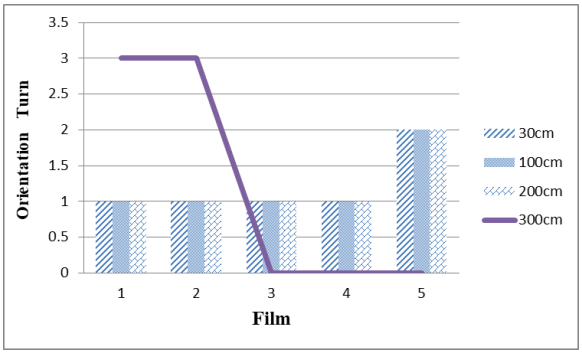


Figure 18. Look-up reaction (distances)



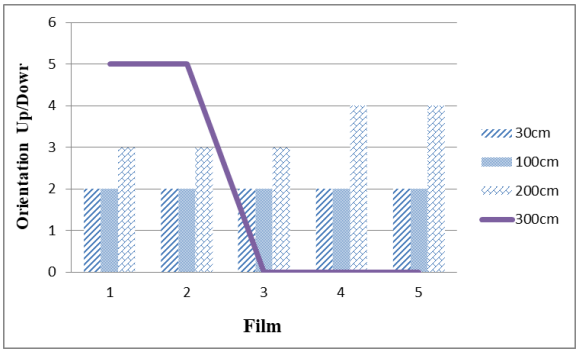


Figure 19. Combat reaction (distances)

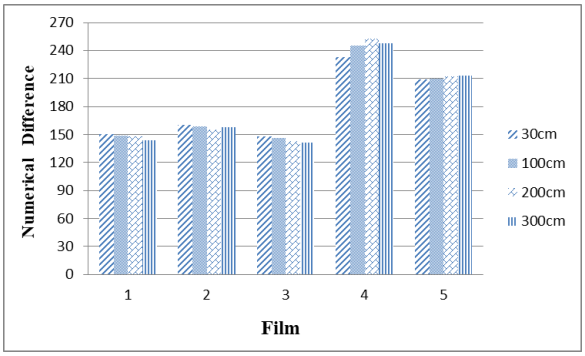


Figure 20. Victory reaction (distances)

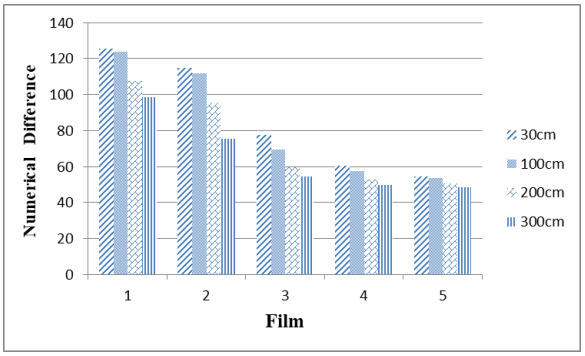
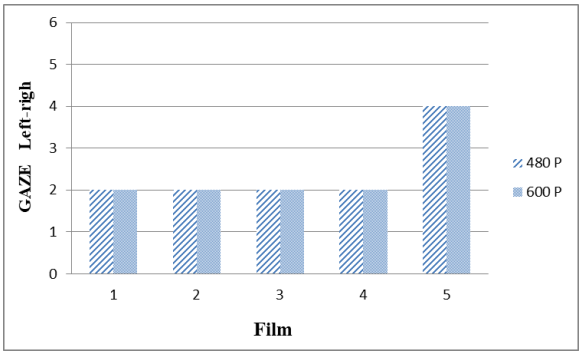


Figure 21. Escape reaction (distances)



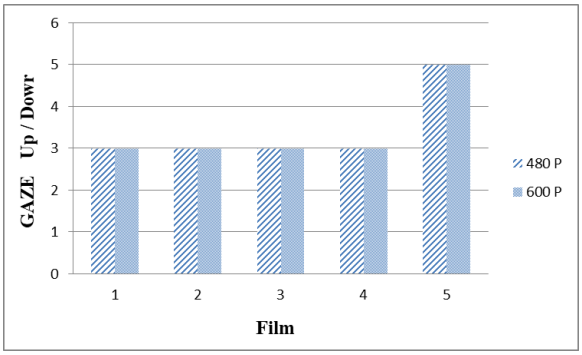


Figure 22. Freeze reaction (resolutions)

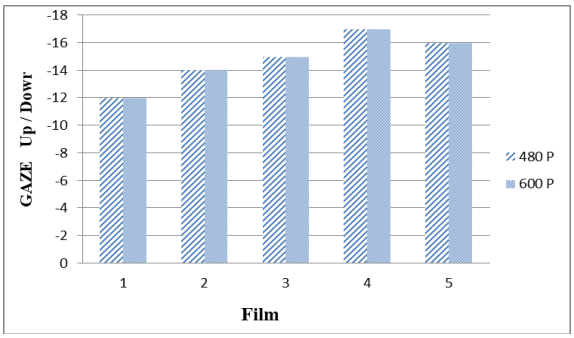


Figure 23. Territory reaction (resolutions)

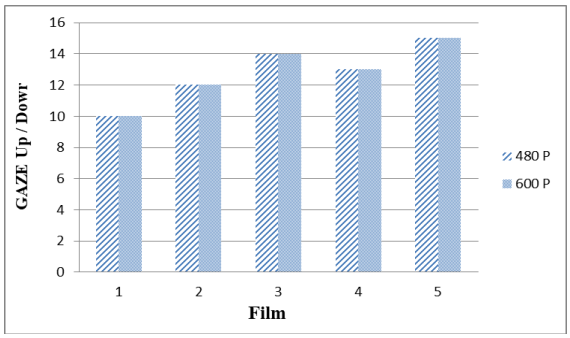


Figure 24. Look-up reaction (resolutions)

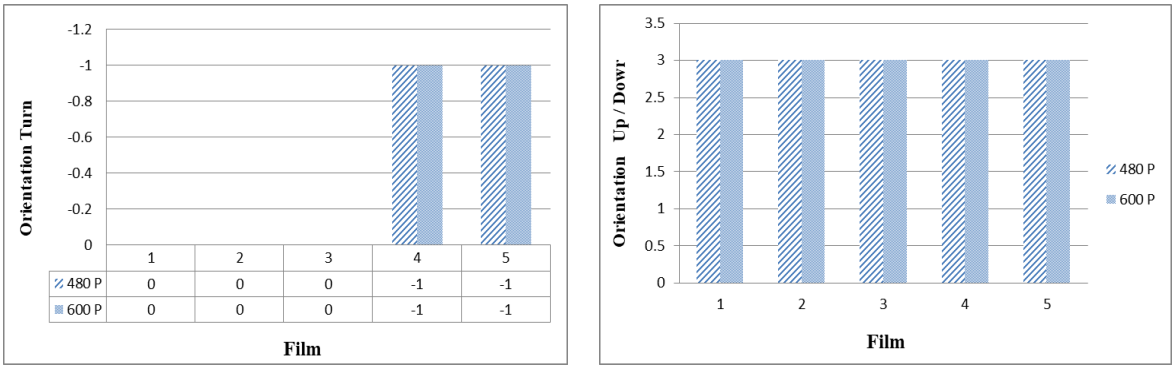


Figure 25. Combat reaction (resolutions)

4. CONCLUSION

AI is advantageous in recognizing micromovements, and when a subject is objectively captured on camera, a computer can obtain relevant data for processing. High-quality and efficient recognition can be achieved simply by using a camera and microphone. An AI system can be utilized to assist investigators in interpreting micromovements, enabling investigators to focus on the back-and-forth of questions and answers during an interrogation. Including AI in case investigations can improve the efficacy and efficiency of interrogations.

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