

Design of an expert (EC) judging program to evaluate the performance of the front handspring skill on the vaulting platform in artistic gymnastics.

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Abstract

The researcher designed an artificial intelligence program that simulates the judge's experience in making a decision through angles, measurements, possible errors, and movement paths of performance, which were pre-defined to be a database on which the designed program is based in making a judgment according to the international law of gymnastics in evaluating the performance of the front jump on the vaulting platform for men. It is hoped that it will be the appropriate solution to support the judges' decision in a more objective manner. The aim of this study was to design an artificial intelligence program using expert systems technology to evaluate the performance of the front foot vault skill in men's artistic gymnastics. The research methodology employed was descriptive, utilizing the interrelationship and causal relationships approach, as it was deemed most suitable for the nature of the problem. The researcher defined the population as (30) federal gymnastics judges in Iraq. A purposive sample of (10) federal judges was selected to evaluate the performance of male gymnasts in executing the front foot vault on the vault platform after completing the judging program for the men's artistic gymnastics front foot vault. Following initial pilot trials and confirmation of the program's scientific foundations, the researcher conducted the main trial on September 25-27, 2025, in the Samir Khammas Hall. International and local judges were present, and the top 20 performances were judged. The judges evaluated the performances, and the expert systems judging program, designed concurrently, provided all necessary requirements for the trial were met, including lighting, equipment, and cameras, which were positioned vertically on the vault platform. At a distance of six meters from the platform so that the beginning and end of the performance can be seen, and the laptop is placed in a location close to the camera so that it does not obstruct the judges' view.

Introduction

Interest and scientific progress in information technologyThis has led to easier handling of situations and data, saving time and effort, making life simpler, and enabling more precise information processing to solve problems encountered in daily and professional life. Artificial intelligence is one of the most important modern technological methods for dealing with information, having been instrumental in solving numerous problems at all levels, particularly through expert systems and deep learning. These rely on knowledge bases, allowing machines to simulate human judgment and computer vision, resulting in faster and more accurate outcomes. Since sports in general, and gymnastics in particular, are human activities, they are subject to many challenges related to skill performance. The sport has witnessed significant development in terms of skill requirements and the creation of numerous new skills, which in turn has led to the development of specialized equipment, including the new vaulting platform. (Khargan,(2025).

The importance of the research lies in the researcher's endeavor to find an arbitration tool using expert systems technology and artificial intelligence to generate an accurate scientific design that helps in moving from traditional visual observation to computer vision evaluation capable of providing more accurate data and issuing a score that guarantees the player's right in record time.

Research Problem:Arbitration, in general, is the issuance of judgments and decisions regarding a specific case, activity, or behavior, which determines the degree of that action according to pre-established criteria.andThe arbitration panel platform consists of several committees, the most important of which is the arbitration committee (Committee (D) is specifically responsible for the difficulty of the skill, in addition to other tasks, and Committee (E) is responsible for evaluating the skill performance, in addition to other tasks.(Khargan,(2020)

This prompted the researcher to design an artificial intelligence program that simulates the judge's experience in making a decision through angles, measurements, possible errors, and movement paths of performance, which were predetermined to be a database on which the designed program is based in making a judgment according to the international law of gymnastics in evaluating the performance of the front jump on the vaulting platform for men. It is hoped that it will be the appropriate solution to support the judges' decision in a more objective manner.

Research Objectives

- 1- Designing an AI-powered expert systems program to evaluate the performance of the front jump skill on the vaulting platform in men's artistic gymnastics.
- 2- Identifying the differences between the final score of the designed program and the final score of the judges in evaluating the front jump on the vault in men's artistic gymnastics.

Research Hypotheses

- 1- There are significant differences between the final performance score of the designed program and the human judges' evaluation of the men's front jump on the vaulting platform.

Research Areas

- Human field: Referees of the Iraqi Gymnastics Federation.
- Spatial scope: Training center hall in the governorates of Maysan, Dhi Qar and Baghdad.
- Time frame: 1/1/2025

Research methodology and field procedures:

Research Methodology:

The descriptive approach was used in the style of interrelationship and causal relationships studies because it is suitable for the nature of the problem to be solved.

Research population and sample:

The researcher identified the community, which is the federal gymnastics judges in Iraq, numbering (30) federal judges. The research sample was determined in a purposive manner and consisted of (10) federal judges to evaluate the performance of the players in executing the front handspring on the vaulting platform for men's artistic gymnastics.

Methods, equipment, and tools used in the research:

Data Collection Methods:

- 1- Note.
- 2- Arabic and foreign sources.
- 3- Personal interviews: The researcher conducted personal interviews with some specialists in the field of gymnastics to benefit from their opinions regarding the variables in the research. Appendix (1).
- 4- Questionnaire form for determining performance stage discounts, Appendix (2).

- 5- Tests and measurements.
- 6- The international communications network (the Internet).
- 7- Performance Evaluation Form Appendix (4).

Devices and Tools:

- ❖ A video camera of the type (Sony) Japanese made, with a frequency speed of 300 images/second, quantity (1).
- ❖ Manual calculator of the type (thn) Made in China.
- ❖ Laptop computer (ThinkPad is Irish-made).
- ❖ Software and applications used in computers for motion analysis.
- ❖ The scale of the drawing is used to determine the true value that appears in the film.

Field research procedures:

Expert Systems Program for Judging the Forehand Jump on the Vaulting Platform in Gymnastics. The researcher began designing a program to judge the technical performance of the front handspring ((vault) in gymnastics, and the work was done in several stages, which are as follows: Phase One: Planning and defining the general requirements and objective of the program, where an automated program was built to judge and evaluate the players' performance in the front handspring skill (The Handspring Vault in artistic gymnastics. This provides an objective evaluation based on technical criteria according to the International Gymnastics Code, considering biomechanical variables affecting the skill's technical performance, such as jump height, landing accuracy and stability, and body angles during all phases of movement. The researcher determined all the program's technical requirements after interviewing specialists and experts in biomechanics, specialized programmers, and photographers to discuss camera type and shooting resolution. The order of ideas in expert systems was as follows:

Inputs (Database or knowledge base inputs:

- a- A large collection of video clips of the handspring vault performance. To form a database for teaching the program.
 - b- A set of standards according to the International Gymnastics Code, which consists of values for each measure of angles and inclination along the line of performance and the corresponding deductions approved by the Code, as in Appendix (5).
- 2- The tools used in the reasoning engine according to cognitive facts:
- a. Python (Python): as a primary programming language because it is easy to use, as it is more advanced and flexible than other programming languages.
 - b. OpenCV: A specialized Python library for video processing, frame analysis, and video analysis, suitable for researchers' work in skill segmentation and tracking body points at all stages of performance.
 - c. Computer vision models (Computer Vision Models): To sense body posture (Pose Estimation) and track joint movement during performance to give a clear picture of the performance.

Phase Two: Data Collection and Analysis

1. Collecting video clips: The researcher compiled a wide library of videos of the front jump on the platform in artistic gymnastics, which includes professional performances and other attempts at different degrees, to form a knowledge base for the program, enabling it to read and classify the performance and place it in a suitable position through the program's ability to track the points and variables affecting the performance. This is what was done in the first exploratory experiment.

2. Video analysis using OpenCV: The researcher segmented each video clip using the same library into a series of images (frames). This enabled the program to analyze each moment after training it on the performance stages and the beginning and end of each stage, where ten frames were created for each stage according to the data entered into the program.

3. Defining the main judging criteria: based on the rules of the International Gymnastics Federation (FIG)(FIG), the researcher identified the criteria that the program will evaluate, according to the basic stages of skill performance, which are:

- A. Pre-flight: The jump path and all body angles with height and tilt from the vertical line from the moment the glove leaves the jump upwards until the moment before touching the platform.
- B. The support phase, from the athlete's contact with the vaulting platform until leaving it, monitoring angles, tilt from the vertical, and height of the body's center of gravity.
- C. Second flight phase (Post-flight): From the moment of leaving the platform until landing, monitoring the height of the body above the ground level and above the platform, all body angles, all body points, body extension, and the full range of motion represented by the height of the center of gravity level during the body's rotation in the air.
- D. Landing phase: The moment when any part of the player's body touches the ground, where the program monitors the accuracy of landing on the feet, the straightness of the body, and the number of steps after landing.

3. The third stage: Building the logic of arbitration using expert systems (computer vision models)

1. Body position sensing (Pose Estimation): This was the most important step. The researcher used computer vision models within the program to analyze each frame of the video and precisely determine the positions of the body's joints (such as the knees, elbows, shoulders, etc.). This allowed him to track the player's movement and determine the body's angles at every moment in order to calculate the opponent's positioning at that angle, as the program had been programmed to do.

2. Applying the rules: The researcher prepared Python code to implement the arbitration criteria he had defined in the previous stage. For example:

- A. If the knee joint angle during support is less than 180 degrees by 15 degrees, 0.1 degrees are subtracted, and so on until all possible angles are activated. (See Appendix 5)
- B. If there is a bend in the knees or a step forward or backward during landing, points will be deducted according to the international law and as explained in Appendix (5).
- C. Height is calculated by tracking the highest point reached by the player's center of gravity, which is the player's hip point. A model is provided as a template to teach the program the precise required height and movement paths of possible models; points are deducted from the performance if the height falls below this point.

3. Score compilation: All these partial assessments and all performance stages were compiled to create a final assessment score for the jump, to which the overall performance score and the skill-specific difficulty score were added, according to international law as explained in (5).

Phase Four: Testing and Improvement

Model Accuracy Testing: The researcher tested the program on new, previously unseen video footage as a project overview. This enabled him to build a comprehensive desktop application for analyzing the performance of the men's forward handspring on the vaulting platform, based on biomechanical variables. The application allows the user to record the jump directly via the camera or upload a previously saved video. The application then automatically analyzes the video, breaks down the movement into phases, calculates the deductions stipulated by international

law based on specific rules, and finally provides a final score along with a detailed performance report. This report includes the final score and deductions for each phase of the performance, a performance flow graph, maximum body height, a computer vision video of the performance, and displays all results in a dedicated desktop file in Excel format.

Phase Five Outputs (Outputs):

1. Final grade.
2. A detailed report showing the points of bending, angles, tilt, and range of motion in the performance.

Phase	Knee	Ang	Hip	Angle	Shoulder	Elbow	An Elbow	An Leg	Distar	Legs	Ded	Total	Phase	Deduction
1	143.3	0.3	114.1	0.3	50.4	0	128.4	0.5	10.3	0.5	1.6			
3	119.4	0.1	92.7	0	28.4	0	141	0.5	12.4	0.1	0.7			
4	137	0.1	110.7	0.3	72.6	0.5	145.9	0.5	7.8	0.1	1.5			
5	159.5	0.3	162.2	0.3	77.3	0	47	0	7.7	0.1	0.7			

Final Summary	
Jump Heig	49
Total Perf	4.5
Fixed Ded	0.2
Total Dedi	4.7
FINAL SCO	6.9

Images (1) illustrate the final degree, points of flexion, angles, inclination, and range of motion in the performance.

3. A graph that represents the path of movement in a way that can be understood and dealt with mathematically.

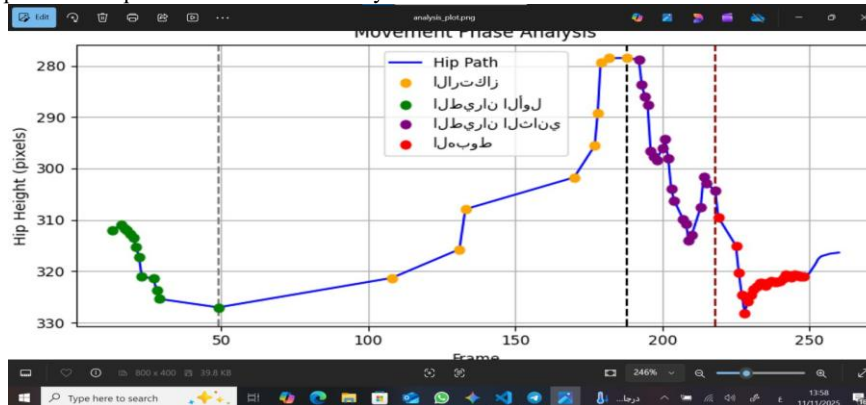


Figure (2) shows a diagram representing the path of movement

4. A video demonstrating computer vision of performance and tracking of body point movements.



Figure (3) illustrates the computer vision of performance

5. Program scope expansion: The program can be modified to judge other gymnastics movements.
6. Adding a graphical interface: A graphical user interface can be developed (The GUI is easy to use for coaches and athletes).

Key features of the application:

1. Live analysis: Recording video from the camera and analyzing it immediately, according to biokinematic variables.
2. Download video: Analyze video files on your device with the same efficiency.
3. Comprehensive Report: Clear presentation of results (final score, discount table, computer visualization, graph).
4. Permanent Record: Each analysis session (video + results) is saved in a record that can be easily accessed. This record is in Excel format.
5. Re-analysis: The ability to re-analyze older videos from the record.

Pilot Tests:

First: The First Pilot Test: To establish the most important foundations upon which the researcher could successfully implement the main experiment, the researcher conducted a pilot test in the gymnastics training center in Maysan Governorate on March 1, 2024, at 3:00 PM. The pilot test was conducted with seven athletes. The objectives of this test were:

- 1- To obtain the largest possible number of performances to enrich the program's knowledge base.

- 2- To determine the sufficient time for the research sample to perform the performance.
- 3- To ensure the suitability and appropriateness of the testing location.
- 4- To verify the functionality of the camera. 5. Ensuring the number and adequacy of the support team members.
- 5- Assessing the participants' understanding of the tests used.
- 6- Addressing any obstacles or problems that the researcher might encounter.

Main Experiment: After completing the judging program for the front vault on the vault platform in men's artistic gymnastics at all stages, and after the initial exploratory trials and confirmation of the program's scientific foundations, the researcher commenced the main experiment on September 25-27, 2025, in the Samir Khammas Hall. International and local judges were present, and the top 20 performances were judged. The performances were evaluated by the judges and electronically using the expert judging system designed concurrently. All experiment requirements, including lighting, equipment, and cameras, were ensured. The camera was positioned vertically on the vault platform, six meters away, allowing for a view of the beginning and end of the performances. The laptop was positioned near the camera without obstructing the judges' view. 3-4-6 Statistical Methods:

The data were processed using the SPSS24 statistical software.

4- Presentation, Analysis, and Discussion of Research Results:

4-1 Presentation, Analysis, and Discussion of Final Scores for the Program and Judges:

Table No. (1) shows the arithmetic means, standard deviations, r, t, and sig values for the final scores.

Sig	T	R	The program.		The referees.		The variable Technical performance	No
			A	S	A	S		
0.06	2.10	0.027	0.88	7.75	0.47	8.32		1

Table (1) shows the arithmetic means, standard deviations, r, t, and sig values for the final scores of the designed program and the final score of the human judges in evaluating the men's front vault performance on the vaulting platform in artistic gymnastics at the Clubs Championship held by the Central Federation. After displaying and statistically analyzing the results to determine the difference between the final score of the designed program and the traditional judges' score, the arithmetic mean for the judges' final score was 8.32, while the arithmetic mean for the designed program was 7.75. The standard deviation for the final score of both the designed program and the judges' score was 0.47 for the judges and 0.88 for the designed program. The t-value was 2.10 at a significance level of 0.06. Since the t-value was greater than the standard significance level of 0.05 or 5%, the observed difference between the two means is not statistically significant; that is, there are no statistically significant differences. The correlation coefficient (r) was 0.027, very close to zero. This indicates that the judges, on average, gave higher ratings to the technical performance compared to the program's estimate. The researcher attributes this to the judges' inability to accurately perceive the angles (Barreto, J., & Henriques: 2023) due to the speed of skill execution and the angle of view relative to the computer's vision and the accuracy of the designed program. This program is considered a suitable tool for solving various problems because it handles a vast amount of data and variables. It acts as a massive information pump, processing data related to numerous variables (Baltzan, Paige & Phillips, Amy, 2009). Therefore, the standard deviation of the judges' scores is lower than the program's scores. As shown in Table 1, the lower standard deviation indicates that the judges' scores were more similar, suggesting a degree of agreement in their evaluation or consistency in their measurement compared to the designed program. The researcher attributes this to the judges having a uniform or similar level of vision. Therefore, the similarity in the judgment is based on the program's ability to determine the value of the angle committed during the performance, thus enabling it to identify the appropriate deduction. The deduction varies between angles in proportions corresponding to the angle's magnitude in points. This is something the human eye cannot determine under the conditions and constraints of performance, such as speed, angle of vision, and the time it takes to announce the score. The judges are obligated to announce the score within a specific timeframe after the exercise is completed. In other words, the judges are required to write down their deduction observations and submit them within a maximum of 60 seconds from the player's completion of their phrase, depending on the device and the tournament. The aim is to quickly compile the execution (E) and difficulty (D) scores and announce the final score immediately after the initial calculation and review process. While the rules do not specify a precise number of seconds for announcing the final score, they emphasize the principle of immediate announcement and set tight time limits for the judges to ensure that this announcement is as quick as possible (usually no more than one minute in major tournaments) (Ziad Tariq and Abdul Karim Marai: 2025). In contrast, the program's final score announcement time did not exceed three seconds, and it was also saved in a special file for future reference. It can be easily transferred and generalized. Although the judges' scores were numerically higher, this difference cannot be generalized or considered a genuine and systematic difference in evaluation. It may be due to chance or random variation, indicating a very weak and positive correlation between the judges' final score and the final score of the designed program. This conclusion suggests that the program's evaluation criteria differ from the judges' evaluation criteria. There is almost no agreement between them; an increase in the program's score does not necessarily correspond to an increase in the judges' score, and vice versa. Therefore, the final result is that there are no statistically significant differences between the two means (Sig. 0.05). That is, there is no significant correlation or linear relationship between the program's evaluation and the judges' scores, as r was close to zero.

Conclusions and Recommendations:

Conclusions

- 1- The designed program contributes to awarding a final score to the athlete after the performance, ensuring their right to a fair evaluation of the men's front handspring vault.
- 2- The designed program is capable of creating a personal file for each athlete, and for all athletes, including a video demonstrating the performance along with a table of all variables and their corresponding deductions in Excel format, which can be accessed at any time.

Recommendations are:

- 1- Emphasizing the use of the designed program to support judging in local and national artistic gymnastics championships for men.
- 2- Utilizing and developing the designed program to include more challenging skills across all six apparatuses used in gymnastics.

References

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