# MODELS OF EXPERT SYSTEM AND DECISION-MAKING SYSTEMS FOR EFFICIENT ASSESSMENT OF POTENTIAL AND ACTUAL QUALITY OF BASKETBALL PLAYERS

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## Abstract:

The presented article is a survey of issues, approaches and accomplishments of both the research and of theoretical studies on models and systems for basketball, primarily, performance prediction and assessment that the authors, their associates and colleagues have conducted in the last decade in Croatia and Slovenia. Substantial characteristics of both expert and decision-making systems are described in the article, as well as the relation between the potential and the actual quality of players. Also, the models of decision-making systems are presented that have successfully applied as a helpful means in the orientation (guidance) of players to certain positions in the game, in their selection and in managing the training process.

***Key words:*** *basketball, expert system, decision-making system, potential of players, playing efficiency, performance, orientation, selection*

## INTRODUCTION TO EXPERT SYSTEMS

In their research the basketball experts and scientists try to improve the processes of selection and orientation of basketball players and to attain higher levels of efficiency of the training process by designing and using multi-parameter expert systems or a decision-making system (Trninić, 2000). The very process of the creation of various models is a true challenge to every expert because through the multi-parameter attributes of a particular sport game (that first have to be recognised and defined), he/she needs to establish the actual elements of the proposed model and their interrelations within the model in question, as well as to eliminate any less important variables (elements). The development and improvement of flexible models of the aforementioned systems is a long lasting process based on a scientific approach, that manifests itself in the elimination of errors, in changes of the model structure and in the introduction of new elements.

The presented article is a survey of issues, approaches and accomplishments of both the research and theoretical studies on models and systems for basketball, primarily, the prediction and assessment of performance that the authors, their associates and colleagues have conducted in the last decade in Croatia and Slovenia. Therefore, only the general and the basic outlines and inferences of several selected studies are presented here up to the level of indispensable for the explanation of concepts in question. For more detailed insights into the research studies' particularities, the authors suggest consulting the references denoted.

Expert systems and decision-making systems are computer programmes that function as experts in a certain problem field. The computer programmes are generally regarded as more capable and sophisticated than humans since they can find and eliminate errors on their own because they incorporate both expert knowledge and computer's powerful capacities. Expert systems and decision-making systems have emerged from the development of computer technology, especially in the field of artificial intelligence (Chankong and Haimes,1983; Mallach, 1994). They consist of the knowledge base and the shell. Usually, the shell is separated from the knowledge base. This means that it is possible to use different knowledge bases with the same shell. The typical structure of an expert or decision-making system model is represented in Figure 1.

Such a hierarchically arranged structure clearly displays positions and relations among the various performance factors at certain hierarchical levels. Further, it is more than obvious how the higher level factors inherit the attributes of factors at lower levels (Dežman, 1992, Dežman, Erčulj, 1995, Erčulj, 1998, Kurent, 1998, Trninić, Dizdar, Dežman, 2000).

Decision-making rules determine the relations among factors comprised in a decision-making tree and the way of calculating grades at all higher (derived) levels of the decision-making tree. The overall grade of the player's quality is calculated on the basis of the grades of basic factors (leaves) and their coefficients of importance (ponders or weights). Weights or ponders determine the importance or contribution of a certain factor to the performance grades at each tree level and to the overall grade. They are created by a group of experts who evaluate the contribution (weight or ponder) of a chosen performance factor for the best players in an absolute class or in a selected youth group (Jošt, Dežman, Pustovrh, 1992; Trninić, Dizdar, 2000).

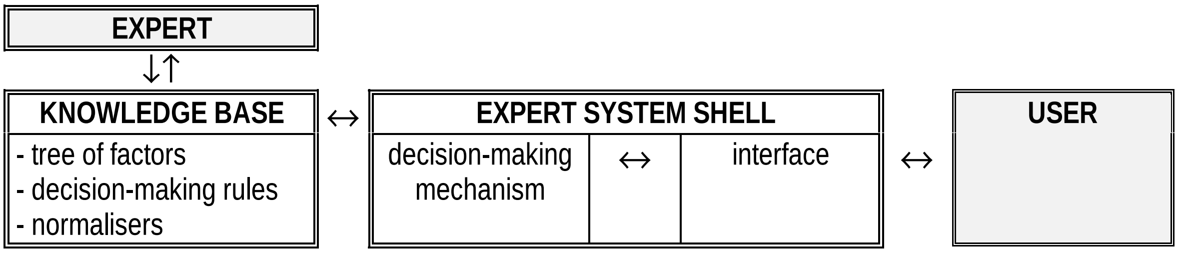


***Figure 1**: Typical structure of both an expert system and of a decision-making system.*

Knowledge base consists of performance factors (criteria), decision-making rules and normalisers, that have to be created in a computer-acceptable way, fitting the shell of the expert or decision-making system. Therefore, the criteria are most frequently expressed in the form of multi-degree linear mathematical models that are hierarchically arranged in a structure (see Figures 3, 4, and 5). These models are regarded as the most appropriate ones since they are the closest to the problems of sports (Leskošek, Bohanec, Rajkovič, Šturm, 1992; Leskošek, 1996). The hierarchical structure of efficiency in sports and performance criteria are shown in the form of a ″decision-making tree″. In sport games, the trunk of the tree represents usually either the potential or the actual performance in a game. Both the thicker and the thinner branches are factors of performance (player's characteristics, abilities, and the efficiency factors of playing) that influence it, whereas the leaves are the lowest factor categories that influence the performance at all the upper tree levels (test scores, grades, game statistics, etc.).

Normalisers (or standardisers) are extreme values of scores achieved in a certain tree leaf (a variable), that help transform the actual score into a quantitative grade (from 1 to 5) or a quality grade (failure, acceptable, good, very good, excellent). The scores are first transformed into standard $z$-values, $t$-values, or centile values, and then they are classified in categories from 1 to 5. If the grades of all factors are presented from 1 to 5, such a standardisation is not necessary. Additionally, it is necessary to determine the direction of impact of certain factors in a particular tree leaf. The relation is progressive or ascending when the higher result is the better one, or regressive or descending if the lower score is the better one (reverse-scaled variable). The relation can also be a combined one if it is ascending up to a certain point and then descending from that point downwards, or vice versa.

Expert system shell consists of the decision-making (inference) mechanism and the interface. The decision-making mechanism is a part of the expert system or the decision-making system that consists of the problem solving algorithms. The user-system interface is concerned with an appropriate communication between a user and a system . Versatile shells of expert systems and decision-making systems are implemented in sports today (Bohanec and Rajkovič, 1990; Leskošek, Bohanec, Rajkovič, Šturm, 1992; Leskošek,1995,1996).

## CORRELATION BETWEEN THE POTENTIAL OF PLAYERS AND THEIR PERFORMANCE

It is possible to assess the quality of a basketball player by two means: through assessment of his/her anthropological attributes or characteristics (potential quality, current capabilities) and/or through assessment of his/her playing efficiency and overall performance (actual quality).

The degree of harmony or conformity between the final results obtained by the two models (potential determination – P, and performance assessment - I) determines the applicable value of data (expressed in the models of the potential and the game performance of basketball players) for the daily practice of the basketball players specialisation, or for selecting the best or the most promising players, or for the training process management. Integrative models, comprising both the potential and performance evaluations, should have the highest degree of harmony since they include all factors responsible for the quality of play.

Due to the great complexity of the basketball game and the variety of roles the players accomplish in it, both potential and their overall performance (actual quality) may assume versatile structures. It means that players achieve the same level of either the potential quality or of an overall performance through different ways or combinations of factors. At the same time it should be remembered that the structure of factors of a player's potential, being specific for him/her, determines the specific structure of factors of his/her overall performance. Therefore, not only are the final values (grades) of both the potential and the overall performance important, but the profile (quality, quantity and structure) of the incorporated factors seems to be even more important.

A coach can, by means of an (individualised) adequate training programme(s), initiate and control the development of most of these factors and their interrelations, to improve them to the level that will allow the player's partial or total potential and overall performance to be enhanced.

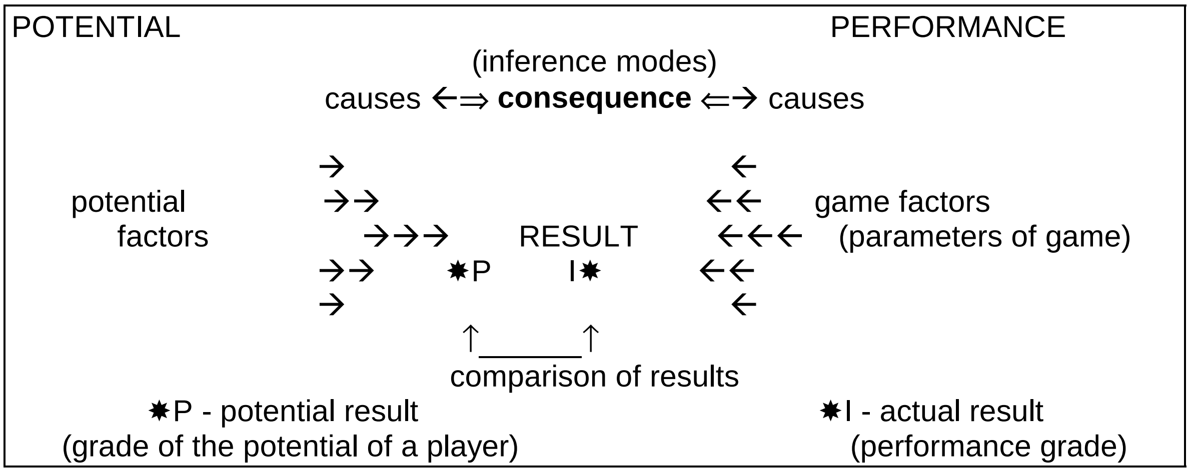


***Figure 2**: Correlation between the potential of players and their performance (modified according to Jošt, Dežman and Pustovrh, 1992).*

## POTENTIAL QUALITY AND ACTUAL QUALITY (OVERALL PERFORMANCE)

The potential quality of a basketball player is the current level of development or the status of his/her abilities, attributes, skills and knowledge that are a prerequisite for achieving a high level of overall performance (actual quality of the basketball players). Potential values are very stable. Their changes depend mostly on the impact of the player's growth, maturation and development (ontogenetic anthropological development), on the one hand, and on the influence of the training processes, on the other. The actualisation and exploitation of the potential in a game depends on several factors. The most important factors are the very quality of the potential itself (aptitude for basketball), then the degree of compatibility, the correspondence between the assigned role and the potential of a player, the quality and the properties of the player's own team play, and the last, but not the least, the quality and style of the opponent's play.

So far, several models of expert systems and decision-making systems aimed at the partial potential of basketball players assessment were designed and tested (Dežman, 1992, 1996; Jošt, Dežman and Pustovrh, 1992; Dežman and Erčulj, 1995; Leskošek, 1996). The results of these research studies revealed a high correlation of the potential of players with their performance. One of the decision-making systems is presented in Figure 3 (Jošt, Dežman and Pustovrh, 1992).

The assessment of players' performance, his/hers actual motor behaviour on the court, is a systematic description and evaluation of the actual qualities of basketball players manifested in the game, under demanding competitive and stressful conditions. The overall performance grade (actual quality) of basketball players embraces all the relevant factors of the actual quality of a player manifested in a game or a competition evaluated by experts (Figure 4) (Trninić, Dizdar, 2000), whereas the partial performance of a player consists only of those factors that are recorded by the game statistics (situation-related efficiency indicators). The latter is called playing efficiency (Figure 5) (Jošt, Dežman and Pustovrh, 1992).

The proposed expert decision-making system is based on the scientific papers by Trninić and associates (Trninić, Perica and Dizdar 1999; Trninić and Dizdar, 2000; Trninić, Dizdar, Dežman, 2000).

Characteristics of the model and its utilisation have been described in the publications by Jošt, Dežman and Pustovrh (1992) and Kurent (1998).

Overall performance (actual quality) and playing efficiency of players are not as stable, neither in level nor in structure, as their potential quality. The quality of an opponent and his style of play has a strong impact on the observed variability. In other words, both the structure (profile) and the level of playing efficiency and performance of a player strongly depends on the opponents. It is also well-known that the mentioned volatility is the smallest with the best and worst players, whereas it is the largest with average players.

Therefore, it is very difficult, if at all possible, to design a practical and yet comprehensive expert decision-making system to assess and evaluate the overall performance. Nevertheless, a coach must have at his/her disposal a consistent tool which allows for direct and/or indirect evaluation of both the quality and the specificity of performance of his/her players, as well as the status of athletic conditioning or preparedness by applying the proposed models. The expert must always be very careful and prudent when interpreting the output data on anybody's actual quality and he/she must by no means rely on a single observation or report, but must accept it as a long-term and never-ending process of observations and analyses. The application of the mentioned models can enhance the training process efficiency, and the effectiveness of selection and orientation of players to "their" roles and positions in the game.

| | | | | Normalisers | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | marks | >=4.5 | >=3.5 | >=2.5 | >=1.5 | | |
| | Ponder B | Ponder K | Ponder C | excellent | very good | good | acceptable | RP | |
| USPJEŠNOST | 100.0 | 100.0 | 100.0 | | | | | | Potential of a player |
| ! | | | | | | | | | |
| !_MorfZnac | 30.0 | 40.0 | 50.0 | | | | | | Morphological characteristics |
| ! !_VzdRaz | 14.0 | 20.0 | 24.0 | | | | | | Longitudinal extensiveness |
| ! ! !_AV | 6.0 | 9.0 | 11.0 | >=94 | >=70 | >=31 | >=7 | P↑ | Body height |
| ! ! !_ADV | 8.0 | 11.0 | 13.0 | >=94 | >=70 | >=31 | >=7 | P↑ | Reach height |
| ! !_ObsegMasa | 12.0 | 16.0 | 22.0 | | | | | | Circumferenc. and mass of body |
| ! ! !_Obsegi | 6.0 | 7.5 | 10.0 | | | | | | Circumferences of body |
| ! ! ! !_AONL | 2.5 | 3.0 | 4.0 | >=94 | >=70 | >=31 | >=7 | P↑ | Circumferences of upper arm |
| ! ! ! !_AOSL | 3.5 | 4.5 | 6.0 | >=94 | >=70 | >=31 | >=7 | P↑ | Circumferences of thigh |
| ! ! !_Masa | 6.0 | 8.5 | 12.0 | | | | | | Body mass |
| ! ! !_AT | 2.5 | 3.5 | 5.5 | >=94 | >=70 | >=31 | >=7 | P↑ | Body weight |
| ! ! !_ATAV | 3.5 | 5.0 | 6.5 | >=94 | >=70 | >=31 | >=7 | P↑ | The ratio of AT/AV |
| ! !_MastTkivo | 4.0 | 4.0 | 4.0 | | | | | | Body fat |
| ! !_AKGN | 2.0 | 2.0 | 2.0 | >=94 | >=70 | >=31 | >=7 | R↓ | Skin fold of upper arm |
| ! !_AKGH | 2.0 | 2.0 | 2.0 | >=94 | >=70 | >=31 | >=7 | R↓ | Skinfold of back |
| !_KondSpos | 30.0 | 30.0 | 25.0 | | | | | | Conditional abilities |
| ! !_HitraMoc | 15.0 | 16.0 | 14.0 | | | | | | Power |
| ! ! !_VOS | 6.0 | 6.0 | 5.0 | >=94 | >=70 | >=31 | >=7 | P↑ | Vertical jump |
| ! ! !_S20 | 6.0 | 6.0 | 4.0 | >=94 | >=70 | >=31 | >=7 | R↓ | Sprint 20 m |
| ! ! !_SZS | 3.0 | 4.0 | 5.0 | >=94 | >=70 | >=31 | >=7 | P↑ | Ball pushing in sitting |
| ! !_Hitrost | 9.0 | 8.0 | 5.0 | | | | | | Speed |
| ! ! !_HST | 9.0 | 8.0 | 5.0 | >=94 | >=70 | >=31 | >=7 | R↓ | Quick marching |
| ! !_Vzdrzlji | 6.0 | 6.0 | 6.0 | | | | | | Endurance |
| ! !_T800 | 3.0 | 3.0 | 3.0 | >=94 | >=70 | >=31 | >=7 | R↓ | 800 m run |
| ! !_C12 | 3.0 | 3.0 | 3.0 | >=94 | >=70 | >=31 | >=7 | R↓ | 12 min run |
| !_TehKoor | 40.0 | 30.0 | 25.0 | | | | | | Technical knowledge and coordination abilities |
| !_BrezZoge | 18.0 | 14.0 | 12.0 | | | | | | Moving without a ball |
| ! !_TSS | 5.0 | 4.0 | 4.0 | >=94 | >=70 | >=31 | >=7 | R↓ | Zig-zag running |
| ! !_TTP | 8.0 | 5.0 | 3.0 | >=94 | >=70 | >=31 | >=7 | R↓ | Run, stance |
| ! !_TPS | 5.0 | 5.0 | 5.0 | >=94 | >=70 | >=31 | >=7 | R↓ | Run, stance, jump |
| !_ZZogo | 22.0 | 16.0 | 13.0 | | | | | | Moving with a ball |
| !_HitrVod | 13.0 | 12.0 | 8.0 | | | | | | Quick dribble |
| ! !_VSS | 3.0 | 3.0 | 2.0 | >=94 | >=70 | >=31 | >=7 | R↓ | Zig-zag dribble |
| ! !_VRV | 6.0 | 4.5 | 3.0 | >=94 | >=70 | >=31 | >=7 | R↓ | Various types of dribbling |
| ! !_PPV | 4.0 | 4.5 | 3.0 | >=94 | >=70 | >=31 | >=7 | R↓ | Dribble, passing |
| !_HitrPod | 9.0 | 4.0 | 5.0 | | | | | | Quick passing |
| !_PSE | 9.0 | 4.0 | 5.0 | >=94 | >=70 | >=31 | >=7 | R↓ | Alternating passing in the wall |

*The abbreviations from the left column are explained in the last coloumn on the right.*
*On the left side of the table the structure of the tree is shown. In the second, third, and fourth column are weights (ponders) for a particular position in the game. In the fifth, sixth, seventh and eight column the normalisers are presented in centile values. In the ninth column the relation between certain factors and performance is displayed (RP). That relation can be either of a progressive (P) or regressive (R) nature.*

***Figure 3**: Example of a decision-making system aimed at evaluating the partial potential of basketball players (modified according to Jošt, Dežman and Pustovrh, 1992).*

| | P1 | P2 | P3 | P4 | P5 | | type of a player |
|---|---|---|---|---|---|---|---|
| **ACTUAL QUALITY** | **100** | **100** | **100** | **100** | **100** | **RP** | **grade for the overall performance (actual quality) of basketball players across positions** |
| | | | | | | | |
| **DEFENCE** | **50** | **50** | **50** | **50** | **50** | | **grade for the performance on defence** |
| | | | | | | | |
| RPO | 13,5 | 11,7 | 10 | 8,0 | 7,5 | P↑ | level of defensive pressure |
| PO | 8,7 | 9,0 | 8,3 | 9,0 | 9,3 | P↑ | defensive help |
| BŠ | 3,4 | 4,1 | 4,6 | 5,9 | 7,7 | P↑ | blocking shots |
| OL | 9,9 | 9,1 | 7,7 | 5,7 | 5,4 | P↑ | ball possession gained |
| SUO | 5,2 | 6,5 | 9,7 | 13,6 | 14,0 | P↑ | defensive rebounding efficiency |
| UTO | 9,5 | 9,3 | 9,6 | 7,8 | 6,1 | P↑ | transition defence efficiency |
| IVPO | | | | | | | playing different positions on offence |
| | | | | | | | |
| **OFFENCE** | **50** | **50** | **50** | **50** | **50** | | **grade for the performance on offence** |
| | | | | | | | |
| KL | 6,5 | 3,5 | 3,0 | 2,7 | 3,0 | P↑ | ball control |
| VD | 6,9 | 4,0 | 3,7 | 3,4 | 3,4 | P↑ | passing skills |
| PL | 5,9 | 6,0 | 5,5 | 4,9 | 5,5 | P↑ | dribble penetration |
| ŠVP | 6,1 | 7,1 | 6,5 | 4,1 | 2,4 | P↑ | outside shots |
| ŠUP | 3,3 | 3,9 | 4,9 | 6,4 | 6,8 | P↑ | inside shots |
| SB | 3,9 | 4,9 | 4,1 | 5,0 | 5,4 | P↑ | free throws |
| IOP | 4,0 | 4,6 | 4,6 | 4,7 | 5,1 | P↑ | drawing fouls and three-point play |
| PUB | 2,3 | 2,4 | 3,0 | 5,1 | 5,3 | P↑ | screen efficiency |
| NLB | 3,5 | 5,4 | 4,9 | 3,4 | 3,6 | P↑ | offence without the ball |
| SUN | 1,9 | 2,4 | 4,4 | 6,7 | 7,0 | P↑ | offensive rebounding efficiency |
| UTN | 5,5 | 5,8 | 5,2 | 3,8 | 2,6 | P↑ | offensive rebounding efficiency |
| IVPN | | | | | | | playing multiple positions on offence |

*The abbreviations from the left column are explained in the last coloumn on the right.*
*On the left side of the table the structure of the tree is shown. The highest node represents the grade of the actual quality (overall performance) of a player. In the second, third, fourth, fifth and sixth column are weights (ponders) for a particular playing position.*
*In the seventh column the relation between results achieved in a particular criterion and performance in basketball (RP) is presented. That relation is of a progressive (P) nature in this case.*

***Figure 4**: An example of a decision-making system aimed at assessing overall performance of a player (actual quality) (modified according to Trninić and Dizdar, 2000).*

| | Grades | | Normalisers | | | | |
|---|---|---|---|---|---|---|---|
| | | | >=4.5 | >=3.5 | >=2.5 | >=1.5 | |
| Playing efficiency tree | Weights | RE | 5 | 4 | 3 | 2 | |
| **UI_NA+OB** | **100.0** | | | | | | **PLAYING EFFICIENCY OF A PLAYER** |
| **I_UI _OFFENCE** | **50.0** | | | | | | **efficiency on offence** |
| I I_ **Successful offence** | **26.5** | | | | | | **successful actions on offence** |
| I I I_ **Successful shots** | **24.0** | | | | | | **made throws** |
| I I I I_ 2PTS | 8.0 | P↑ | >=94 | >=70 | >=31 | >= 7 | made 2-point shots |
| I I I I_ 3PTS | 12.0 | P↑ | >=94 | >=70 | >=31 | >= 7 | made 3-point shots |
| I I I I_ 1FT | 4.0 | P↑ | >=94 | >=70 | >=31 | >= 7 | made free-throws |
| I I I_ AS | 2.5 | P↑ | >=94 | >=70 | >=31 | >= 7 | assists |
| I I_ **Unsuccessful offence** | **23.5** | | | | | | **unsuccessful actions on offence** |
| I I_ **Unsuccessful throws** | **16.5** | | | | | | **missed throws** |
| I I I_ M2PT | 7.0 | R↓ | >=94 | >=70 | >=31 | >= 7 | missed 2-point shots |
| I I I_ M3PT | 7.0 | R↓ | >=94 | >=70 | >=31 | >= 7 | missed 3-point shots |
| I I I_ M1FT | 2.5 | R↓ | >=94 | >=70 | >=31 | >= 7 | missed free-throws |
| I I_ TO | 7.0 | R↓ | >=94 | >=70 | >=31 | >= 7 | turnovers |
| **I_UI_DEFENCE** | **50.0** | | | | | | **efficiency on defence** |
| I_ **Successful defence** | **25.0** | | | | | | **successful actions on defence** |
| I I_ **Gained possessions** | **22.5** | | | | | | **gained possessions** |
| I I I_ OR | 7.5 | P↑ | >=94 | >=70 | >=31 | >= 7 | offensive rebounds |
| I I I_ DR | 7.5 | P↑ | >=94 | >=70 | >=31 | >= 7 | defensive rebounds |
| I I I_ ST | 7.5 | P↑ | >=94 | >=70 | >=31 | >= 7 | steals |
| I I_ BŠ | 2.5 | P↑ | >=94 | >=70 | >=31 | >= 7 | blocked shots |
| I_ **Unsuccessful defence** | **25.0** | | | | | | **unsuccessful actions on defence** |
| I_ AB | 25.0 | R↓ | >=94 | >=70 | >=31 | >= 7 | allowed baskets |

*The abbreviations from the left column are explained in the last coloumn on the right.*
*On the left side of the table the structure of the tree is shown. The highest node represents the grade of playing efficiency of players. In the second column are weights (ponders). In the third column the relation between results achieved in a particular closing action and playing efficiency in basketball (RE) is presented. That relation is either of a progressive (P) or regressive (R) nature in this case. In the middle columns normalisers are presented in centile values.*

***Figure 5**: An example of a decision-making system aimed at the playing efficiency of a player assessment (modified according to Jošt, Dežman and Pustovrh , 1992).*

## REFERENCES


2. Bohanec, M., V. Rajkovič (1990). DEX: *An expert system shell for decision support*. *Sustavica*, 1:145-157.

3. Chankong, V., Y.Y. Haimes (1983). *Multiobjective Decision Making*. New York: North-Holland.

4. Dežman, B. (1992). Expertensystem - Model zur Erfolgsprognose der Spieler im Basketball. In: *Proceedings, 6th ICHPER-Europe Congress*, Praga, pp. 111-117.

5. Dežman, B., F. Erčulj (1995). Die Anwendbarkeit des Expertensystem-modells zur Erfolgsprognose junger basketballspieler. In: *Proceedings of International Conference on Science in Sports Team Games, Sports Kinetics,* Biala Podlaska, pp 189 -193.

6. Dežman, B. (1996). Diagnosing morphological, motor and playing status of young basketball players. *Kinesiology*, 28(2).40-45.

7. Erčulj, F. (1998). *Morfološko – motorični potencial in igralna učinkovitost mladih košarkarskih reprezentanc Slovenije* (Doktorska disertacija). [*Morphological-motor potential and playing efficiency of young members of the Slovenian national teams*. Doctoral thesis. In Slovenian.] Ljubljana: Fakulteta za šport.

8. Jošt, B., B. Dežman, J. Pustovrh (1992). *Vrednotenje modela uspešnosti v posameznih športnih panogah na podlagi ekspertnega modeliranja*. [*Evaluation of models of efficiency in particular sport events on the basis of expert modelling*. In Slovenian.] Ljubljana: Fakulteta za šport.

9. Kurent, D. (1998). *Skladnost različnih načinov ugotavljanja učinkovitosti igranja v košarki*. (Diplomska naloga). [*Conformity of different methods for the playing efficiency determination in basketball*. Graduation thesis. In Slovenian.] Ljubljana: Fakulteta za šport.

10. Leskošek, B. (1995). *Program KISS - implementacija IBM PC IT - verzija 1.2*. [Software KISS – implementation IBM PC IT – version 1.2.] Ljubljana: Fakulteta za šport.

11. Leskošek, B., M. Bohanec, V. Rajkovič, J. Šturm (1992). Expert System for the Assessment of Sports Talent in Children. In: *Proceedings of the International Conference on Computer Applications in Sport an Physical Education*. Wingate Institute for Physical Education and Sport and The Zinman College of Physical Education, pp. 45-52.

12. Leskošek, B. (1996). *Komparativna analiza ekspertnih metod z vidika uporabnosti za začetni izbor in usmerjanje otrok v različne športne panoge*. (Doktorska disertacija). [*Comparative analysis of expert methods from the aspect of initial selection for and orientation of children to different sports*. Doctoral thesis. In Slovenian.] Ljubljana: Fakulteta za šport.

13. Mallach, E., G. (1994). *Understanding Decision Support Systems and Expert Systems.* Illinois: Irwin.

14. Trninić, S., A. Perica, D. Dizdar (1999). Set of criteria for the actual quality evaluation of the elite basketball players. *Collegium Antropologicum*, 23(2),707-721.

15. Trninić, S. (2000). *Recognizing, evaluating and encouraging elite basketball players*. Zagreb: Hrvatski košarkaški savez.

16. Trninić, S., D. Dizdar (2000). System of the performance evaluation criteria weigted per positions in the basketball game. *Collegium Antropologicum*, 24(2), 217-234

17. Trninić, S., D. Dizdar, B. Dežman (2000). Empirical verification of the weighted system of criteria for the elite basketball players quality evaluation. *Collegium Antropologicum*, 24(2), 443-465.

# MODELI EKSPERTNIH SUSTAVA I SUSTAVA ODLUČIVANJA ZA UČINKOVITU PROCJENU POTENCIJALNE I STVARNE KVALITETE KOŠARKAŠA


## SAŽETAK

## UVOD

U članku, koji je neka vrsta pregleda, predstavljeni su neki problemi, pristupi i rezultati istraživačkih napora autora i njihovih suradnika iz Hrvatske i Slovenije, objavljeni u posljednjih desetak godina u eksperimentalnim i teorijskim studijama, o procjeni i predikciji uspješnosti u, prije svega, košarkaškoj igri. Opisane su bitne oznake ekspertnih sustava i sustava odlučivanja, kojima košarkaški stručnjaci i znanstvenici nastoje unaprijediti postupke za usmjeravanje i odabiranje košarkaša te za racionalnije upravljanje procesom treniranja. Zatim je opisan odnos između potencijala i stvarne kvalitete igrača, kao i modeli sustava odlučivanja koji se već uspješno primjenjuju. Oblikovanje različitih modela izazov je za svakog stručnjaka zato što s pomoću višeparametrijskih obilježja sportske igre treba utvrditi stvarne elemente i njihove međusobne odnose unutar modela te eliminirati varijable sekundarne važnosti.

## MATERIJAL I RASPRAVA

Ekspertni sustavi i sustavi odlučivanja jesu kompjutorski programi koji se ponašaju poput stručnjaka na nekom problemskom području, samo što su računalni programi kvalitetniji i napredniji budući da su sami sposobni otkriti i otkloniti greške u rješenju. Ekspertni sustavi i sustavi odlučivanja nastali su s razvojem računalstva, odnosno umjetne inteligencije. U njima se udružuju sposobnosti računala i znanje eksperata. Sastavljeni su od baze znanja i ljuske. Najčešće je baza znanja odvojena od ljuske. To znači da za različite baze znanja možemo koristiti iste ljuske. Strukturu tipičnog modela ekspertnog sustava ili sustava odlučivanja prikazuje slika 1.

*Bazu znanja* čine čimbenici uspješnosti (kriteriji), pravila odlučivanja i normalizatori, koje je potrebno oblikovati na računalu prihvatljiv način, odnosno moraju odgovarati ljusci ekspertnog sustava ili sustava odlu-čivanja.

*Čimbenici uspješnosti* najčešće se prikazuju u obliku višestupanjskih linearnih matematič-kih modela koji su hijerarhijski uređeni (slike 3, 4 i 5). Hijerarhijska struktura čimbenika uspješnosti prikazana je u obliku tzv. *stabla odlučivanja.* Deblo stabla u sportu je najčešće potencijal ili uspješnost igrača u igri. Deblje i tanje grane predstavljaju čimbenike uspješ-nosti (osobine, sposobnosti, čimbenici igranja), koji utječu na uspjeh, a listovi čimbenike najniže kategorije, koji utječu na uspjeh na svim višim razinama stabla (rezultati testova, ocjene, statistički podaci s utakmica i sl.).

*Pravila odlučivanja* određuju odnose među čimbenicima, sadržanima u stablu odlučivanja, i način izračunavanja ocjena na svim višim (izvedenim) razinama stabla odlučivanja. Izračunavanje ukupne ocjene kvalitete igrača postiže se na temelju ocjena osnovnih čimbenika (listovi) i njihovih koeficijenata utjecaja (pondera).

*Normalizatori* (standardizatori) rezultata granične su vrijednosti rezultata igrača u pojedinom listu stabla (varijabli), pomoću kojih se stvarni rezultat pretvara u kvantita-tivne ocjene (npr. od 1 do 5) ili kvalitativne ocjene (npr. neuspješan, prihvatljiv, dobar, vrlo dobar i odličan). Rezultati se najprije transfor-miraju u tzv. standardizirane z-vrijednosti, t-vrijednosti ili centilne vrijednosti i s pomoću njih u razrede od 1 do 5. Nužno je odrediti i smjer utjecaja pojedinih čimbenika u pojedi-nom listu stabla.

*Ljusku ekspertnog sustava* čini mehanizam zaključivanja i korisničko sučelje. Mehanizam zaključivanja je onaj dio ekspertnog sustava ili sustava odlučivanja koji obuhvaća algoritme za rješavanje problema, a korisničko sučelje omogućuje sporazumijevanje između korisni-ka i sustava.

*Povezanost između potencijala igrača i njihove uspješnosti u igri.* Kvalitetu pojedinoga košar-kaša moguća je procijeniti procjenom stanja njegovih antropoloških obilježja (kvaliteta potencijala, trenutačnih mogućnosti) i/ili procjenom uspješnosti u igri (stvarna, aktualna kvaliteta) (slika 2). Zbog velike kompleksnosti košarkaške igre i raznovrsnosti uloga igrača u igri, i njihov potencijal i uspješnost u igri (stvarna kvaliteta) mogu biti različito struktu-rirani. To znači da igrači uspijevaju postići jed-naku ukupnu ocjenu potencijala ili uspješnosti u igri na različite načine, odnosno da specifična struktura čimbenika igračeva potencijala uvje-tuje i specifičnu strukturu čimbenika koji odre-đuju uspješnost u igri. Zato nisu značajni samo konačna vrijednost potencijala ili uspješnosti u igri, već i profil (kvaliteta, kvantiteta i struk-tura) njihovih pojedinih čimbenika.

*Kvaliteta potencijala* (potencijalna kvaliteta) košarkaša predstavlja trenutačnu razinu razvijenosti onih sposobnosti, osobina, znanja i vještina koje su pretpostavka za dostizanje visoke

razine uspješnosti u igri (stvarne kvalitete). Vrijednosti potencijala dosta su stabilne. Njihove promjene uglavnom zavise od utjecaja na razvoj igrača tijekom procesa treniranja. Iskoristivost kvalitete potencijala u igri zavisi od više čimbenika. Najsnažniji utjecaj ima sama kvaliteta potencijala, zatim usklađenost dodijeljene igračke uloge s poten-cijalom igrača, kvaliteta i obilježja igre vlastite momčadi te, na koncu, ali nikako najmanje važno, kvaliteta i način na koji protivnik igra.

*Procjena igračke uspješnosti (stvarne kvalitete),* odnosno učinkovitosti njegovog/njezinog motoričkog ponašanja na igralištu, jest sustavno opisivanje i ocjenjivanje stvarnih kvaliteta košarkaša koje iskazuje u igri. Cjelokupna uspješnost u igri košarkaša obuhvaća sve bitne čimbenike (kriteriji) stvarne kvalitete igrača na određenoj utakmici ili natjecanju koje procjenjuju eksperti (slika 4), dok situacijska uspješnost u igri obuhvaća samo one čimbenike koji se bilježe pomoću statističkog zapisa na utakmici (pokazatelji situacijske uspješnosti), koju nazivamo igračka učinkovitost (slika 5).

Ni igračka uspješnost (stvarna kvaliteta) ni situacijska učinkovitost nisu tako stabilne (ni razinom ni strukturom) kao kvaliteta potencijala (potencijalna kvaliteta). Na njihovu promjenjivost vrlo snažno utječe kvaliteta protivnikova potencijala i njegov način igranja. Drugim riječima, struktura (profil) i razina situacijske učinkovitosti i igračke uspješnosti u velikoj mjeri zavisi od protivnika. Poznato je i to da je promjenjivost (nekonzistentnost) najmanja u najkvalitetnijih i najmanje kvalitetnih igrača, a najveća u prosječnih igrača.

## ZAKLJUČAK

Vrlo je teško stvoriti praktičan, a opet sveobuhvatan sustav odlučivanja za procjenu i vrednovanje nečije ukupne uspješnosti (stvarne kvalitete). Ipak, s pomoću predloženih modela trener može neposredno i/ili posredno ocijeniti kvalitetu i specifičnosti djelovanja igrača u igri, kao i stanje njegove igračke pripremljenosti, može utjecati na racionalnije upravljanje trenažnim procesom, kao i na učinkovitije usmjeravanje i odabiranje košarkaša za pojedine pozicije i uloge u igri. Pri tome mora imati na umu da je procjenjivanje stvarne kvalitete pojedinih igrača, a u krajnjoj konzekvenciji, i ekipa, dugotrajan kontinuiran proces promatranja, procjenjivanja, vrednovanja i analiziranja.

***Ključne riječi**: košarka, ekspertni sustav, sustav odlučivanja, potencijal igrača, igračka učinkovitost, igračka uspješnost, stvarna kvaliteta, usmjeravanje, odabiranje*

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