Application of Fuzzy Sets to Formalization of Chess High Level Concepts

Vachagan Vahradyan
RAU, IPIA
Yerevan, Armenia
e-mail: vachaganv@yandex.ru

Nina Karapetyan
RAU
Yerevan, Armenia
e-mail: nina.karapetyan@gmail.com

Maria Stepanyan
RAU
Yerevan, Armenia
e-mail: a_marish_s@yahoo.com

ABSTRACT

An application of a mathematical apparatus of fuzzy sets to modeling of chess high level concepts is considered. Examples of such modeling are described. On the basis of this approach two programs have been developed; Chess_finder for semantic search in base of chess-games and Chess_comment for commenting chess-games by voice.

KEYWORDS

Chess, fuzzy sets, semantic search

1. INTRODUCTION

The problem of formalization of chess high level concepts in the way in which professional chess players operate with them and simultaneously suitable for programming is considered.

It is assumed that the theory of fuzzy sets is adequate for such formalization. Even if it sounds paradoxical, chess is a game essentially uncertain (according to Botvinnik [10]) and fuzzy (according to Zade [7]). Actually it is essentially impossible to define «the strongest move» in the absolute majority of positions. The concept of «a strong move» is obviously a fuzzy concept and seems can be formalized by means of a fuzzy linguistic variable. Such approach to the modeling of chess game gets more and more supporters [11].

2. FORMALIZATION OF SIMPLE CONCEPTS

Let's consider how the idea of fuzzy sets can be applied to chess concepts of the first level (according to E. Pogosyan's and collaborators classification. [3]). E. Pogosyan notices that the absolute majority of chess concepts of all levels except zero-level (rules of chess game) are individualized [1]. In other words, each chess player interprets the general chess knowledge by his own way [4]. This constrain defines our approach to modeling of chess concepts [8, 9].

2.1 Flanks

It is common to divide the chessboard into two flanks – queen's and king's ones. Two sets of verticals F_Q= {A, B, C, D} and F_K= {E, F, G, H} are assigned to these flanks correspondingly. One of essential questions is whether the verticals A, B, C, D on queen's flank and H, G, E, F on king's flank are interpreted in the same flanking extent by chess players. Obviously, the answer is no. Any chess player will tell you as more a vertical is close to the edge of the board as more flanking it is. This subjective approach to «more flanking» concept cannot be formalized by set-theoretic mathematical means. Thus, it is more adequate to apply the mathematical apparatus of fuzzy sets.

So, fuzzy sets of verticals queen's and king's flanks can look like
F_{fQ} = {1/A, 0,75/B, 0,5/C; 0,25/D; 0/E; 0/F; 0/G; 0/H}
and
F_{fK} = {0/A; 0/B; 0/C; 0/D; 0,25/E; 0,5/F; 0,75/G; 1/H}.
Union of fuzzy sets $F_{fQ} \cup F_{fK}$ is a fuzzy set of flank verticals:
$F_{fQ} \cup F_{fK}$ = {1/a, 0,75/b, 0,5/c; 0,25/d; 0,25/e; 0,5/f; 0,75/g; 1/h}.

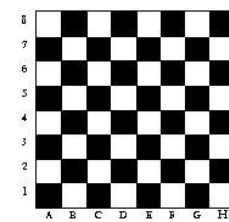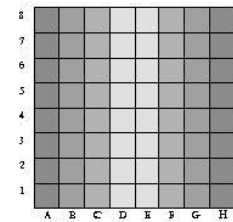Where $\mu_{Ff}(x) = \max (\mu_{FfQ}(x), \mu_{FfK}(x))$.

Fig. 1

Fig. 2

As we can see, the described set correctly reflects our intuitive assumption about more or less flanking chessboard verticals (fig. 2). While the union of usual sets representing queen's and king's flanks gives all verticals – the whole chessboard (fig. 1), and the concept does not reflect "chessboard flanks".

2.2 Center

The control over "the board center" is considered to be strategically very important in chess games. "*The board Center*" in chess textbooks is defined as set of following squares

C = {D4, D5, E4, E5}.

However, a chess player accepts the concept "*center*" wider.
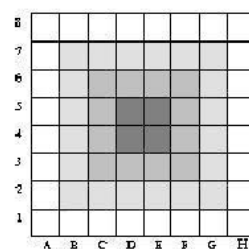

Fig.3

The control over a direct environment of the center (in narrow sense) is considered a little less, but also rather useful and important (fig. 3). So, it is more adequate to describe the concept "*center*" in terms of fuzzy sets. It can be done in the next way:

C_f = {0/A1, ... , 0/A8, 0/B1, 0.25/B2, ..., 0.25/B7, 0/B8, 0/C1, 0.25/C2, 0.75/C3, ..., 0.75/C6, 0.25/C7, 0/C8, 0/D1, 0.25/D2, 0.75/D3, 1/D4, 1/D5, 0.75/D6, 0.25/D7, 0/D8, 0/E1, 0.25/E2, 0.75/E3, 1/E4, 1/E5, 0.75/E6, 0.25/E7, 0/E8, 0/F1, 0.25/F2, 0.75/F3, ..., 0.75/F6, 0.25/F7, 0/F8, 0/G1, 0.25/G2, ..., 0.25/G7, 0/G8, 0/H1, ..., 0/H8}.
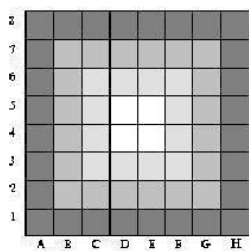
Fig.4

Negation of this set ⌐C_f (we will designate through BE_f), is characterized by the following membership function

$$\mu_{BEf}(x)=1-\mu_{Cf}(x),$$

that reflects fuzzy concept of "*board edge*" (fig. 4).

3. POSITION ESTIMATION

Usually chess players consider the concept of "*position estimation*" in three terms: essentially material, material-positional and essentially positional. Somehow, comparing these three components, the chess player makes a conclusion, for example, that "*the position is more preferable*". It is not difficult to notice that expressions similar to this one can be considered as terms of a linguistic variable "*position estimation*".

3.1 Essentially material component

Essentially material component is an estimation of a position and is calculated as a difference of the sums of nominal values of pieces of both colors presented on the board.

3.2 Material-positional component

It reflects a difference in activity, maneuverability of pieces of the parties. According to Kapablanka "the base of positional overweight is the quantity of fields managed by parties' pieces" [6]. Naturally, it affects their objective value during the game.

We offer a method for estimation of the material-positional component, based on the fuzzy approach to the concept "*piece presence on a board*". This estimation is calculated as the difference of the total price of pieces of the parties and defines a real correlation of forces (material) on the board [2].

$$\underset{f}{\Delta} V_R(f) = \sum V_R(f_{c1}) - \underset{f}{\sum} V_R(f_{c2})$$

3.3 Essentially positional component

This component is estimated by the chess player in a specific way that is different from chess programs. Player defines «sense of position» and based on it estimates current (and counted forward) position. On the same basis the person limits considered moves and combinations by rejecting and not looking through "senseless" positions, i.e. useless from the point of view of sense of the given position.

Saying "sense of position" we understand the most profitable (for the counting party) goal that can be set and achieved from the given position after several semi-moves [1].

The concept of "*sense of position*" is purely individual. While analyzing the same concrete position, chess players with different (as a matter of fact, identical too) qualifications, generally set different goals. It depends from individuality (on style, temperament, experience of the player), but mostly from qualification of each particular chess player.

The goal in chess-game is always a position which is usually characterized in the term that describes some chess concepts. Thus, for formalization of a goal it is necessary to formalize every concepts of lower levels related to it. At first we have decided to consider the most certain goal-concept – "*mate*". There are no different interpretations - mate cannot be more or less. The mate position is accurately formulated by game rules and formalized. Essentially, more difficult, ambiguous and vague concept is "*attack to the king*". In this work we have tried to simulate and investigate this concept. We have broken concept of "*attack to the king*" into four concepts:

- *Preparation of attack to the king;*
- *Attack to the position of the king;*
- *Direct attack to the king;*
- *Mate attack (on the king).*

Positions related to these 4 concepts were defined:
- *LMAK-positions* – Launching positions of Matte Attack to the King. The position is defined by the beginning of the forced mate or a mate by *n* semi-moves;
- *LDAK-positions* – Launching positions of Direct Attack to the King. The position is defined by the beginning of actions on "*the bare king*".
- *LAPK-positions* – Launching position of Attack to the Position of the King. The position is defined by the beginning of actions on destruction of "*pawn cover of the king*".
- *LPAK-positions* – Launching positions of Preparation of Attack to the King. The position is defined by the beginning of arrangement of pieces directed on a position of the king.

We managed to formalize and implement a finding of LMAK-positions. The term "*a hopeless position*" of linguistic variable "*position estimation*" corresponds to them. LDAK-positions are treated ambiguously. In this case correlation of the factors of importance of attacking and protecting pieces is applied [13].

Achievement of any goals in chess is related to the concept of "*a zone of fighting*" that includes all participants in fighting on achievement the set goal with their trajectories. In case of attack to the king, the center of operations is the king, and all those pieces which directly attack the king or "*a belt of the king*" enter into a zone of fighting. The fuzzy set of the pieces attacking the king is being created.

Those pieces which directly attack the king are included into this set with membership coefficient 1. Other pieces are included into the set with as small membership coefficient, as more the quantity of semi-moves is necessary for them to attack the king. The described coefficients are considered as coefficients of importance of attacking pieces. Coefficients of importance for protecting pieces are being calculated by the same way.

4. REALIZATION

We have developed the program Chess_comment [12] which is capable to estimate a position "approximately" like a person and to give out the voice message on position estimation on chess slang in a case of attack on the king.

Based on this approach, it became possible to develop another program – Chess_finder [13], for semantic search (search in concepts) in database of chess positions when the request is made on chess slang.

5. RESULTS
5.1 Program Chess_comment

Chess_comment program has shown good results on estimation of 10 positions from endgames for which grand master's estimations were known. For all checked parties they just repeated grand master's estimations [5].

The result close to grand master's estimations was shown in middlegame positions for 7 positions from checked 10 ones.

5.2 Program Chess_finder

Chess_finder makes search in the base of chess parties by about the same parameters that are used by nowadays commercial search-programs. In addition, our program is capable to make semantic search in accordance with requests formulated in common chess players vocabulary.

For example, it is capable to process the following request: "find Tigran Petrosyan's parties won by blacks with application of Karo-Kann's defense in 1963-1969 and where positions had "*strongly*" or "*absolutely bounded*" pieces."

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