A MODEL OF A HIGH LEVEL CHESS CONCEPT "BEAUTIFUL MATE"

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ABSTRACT
The possibility of the formalization of chess high level subjective concepts, such as: "beautiful mate", "unexpected move" and others is considered.
To analyze these concepts the mathematical apparatus of fuzzy sets is applied and an acceptable correlation between computer and humans estimations of the "beautiful mate" for certain positions is demonstrated.

Keywords
Fuzzy sets, chess concepts, subjective concepts.

1. INTRODUCTION
Specifying chess game Tigran Petrosian, the 9th World Chess Champion, said:
"Chess is a game by form, an art by content, a science by the difficulty of mastering."
This concentration of different aspects of human activity demonstrated for chess is enlightening the difficulties in formalization of concepts of humans.
Modeling human knowledge stays to be one of the stumbling blocks in the way of creating artificial intelligence, in classic-romantic understanding of the problem [1, 2].
In the paper we attempt to formalize mathematically rigorous a very subjective chess concept "*beautiful mate*" to approach to the one used by chess players.
Along with theoretical interest to the model it has also a practical value, since it can be used for semantic search in databases of chess games, when the request is made on a real chess jargon [3].
Corresponding systems can be a very useful in the training of high-level players for matches and tournaments and for teaching the beginners.

2. REFINING PROBLEMER
2.1. Let us list the three main difficulties in formalizing "*beautiful mate*":

The first question sounds rather abstractly: "What is the beauty?"
Almost all philosophical schools of all times gave their own unique definition of the aesthetic category of "*beauty*." In order not to be drawn in this sea of approaches and philosophical views, we narrowed down the consideration of the concept to its application exclusively in the field of chess.

The second issue concerns the fact that even the mate positions or mate moves themselves are not considered in the aesthetic plane. The peculiarity of the situation is in the sense of beauty being developed dynamically in particular segments of games...
It originates from *surprise – anticipation of beauty* (several moves before the mate), and reaches its climax – the overall feeling of beauty, when it is found out that the mate is inevitable. Often it is one or two moves before the mate, but sometimes at the moment of the mate [4, 5].

The third question concerns the subjectivity of the concept of beauty. In fact, for different people the same chess-mate may appear as: *very beautiful, just beautiful* or *ordinary*. It depends on the aesthetic maturity of the person, his temperament, and the brightness of imagination. But most of all it depends on the experience and strength, that is, the qualification of each, who appreciates the chess game [6].

2.2. And so, as the sense of beauty begins from the wonder, and the latter is inextricably linked with the notion of *unexpectedness*, it can be affirmed that the beauty of chess is psychologically interpreted as an aesthetic expression of *positive surprise*. Unexpectedness is not less subjective, but at the same time it is a more tangible – measurable concept.

Then there is another similar question: "*What is the unexpectedness?*"

The answer is a simple observation: a chess player seeks to find and to make such a move, which leads to improve the assessment of the position in his favor [4, 8] ("*expected*" move).
And then, the move leading to a change in the position estimate in favor of the opponent can be safely – firmly called "*unexpected*."
We have applied the technique of *the substitution* of the concept "*beauty*" to the concept "*unexpectedness*".

The rationale for the legality of such substitution is the following fact: all the chess commentators telling about a beautiful move and the beautiful combination are almost always talking about the "sacrifice". Mostly it is a question about the material, rarely – about a positional sacrifice.
As a material sacrifice it is understood the move, resulting a potential loss of a piece, it leads to a deterioration of the material component of the position estimate. Such a sacrifice is either accepted or not from the contender.
By a positional sacrifice it is meant the move, leading to a deterioration of the positional component of the position estimate. For example, a move leading to the deactivation of own piece.
But when, after such moves, it appears that mate is inevitable we come to *the complete sense of a "beautiful move" and a "beautiful mate"*.

3. CONSTRUCTION OF FUZZY MODELS

3.1. Actual coast of piece
For mathematical formalization of the above ideas, we use the previously developed material-positional (M-P) estimate

of the position [7]. It is based on our fuzzy approach to the concept of *"the presence of pieces on the board"* allowing, particularly, to define the concept of *"actual cost of piece"* as follows:

$$V_R(f_j^c) = V_N(f_j^c) * \mu(f_j^c)$$

Here $V_N(f_j^c)$ is the nominal cost of j piece of color c and $\mu(f_j^c)$ – the membership function of fuzzy set.

"*The presence of pieces on the board*" was defined as follows:

$$\mu(f) = \frac{M_R(f)}{M_T(f)}$$

Here $M_R(f)$ is the power of set of fields covered by the piece f in a given position and $M_T(f)$ – the power of usual set of fields covered by the piece f on the centre of the empty chessboard.

3.2. Material-Positional (M-P) estimate of the position

M-P estimate of the position is calculated as the difference between the sums of real values of pieces of both colors:

$$\Delta V_R(f) = \sum_{i=1}^{16} V_R(f_i^{c1}) - \sum_{j=1}^{16} V_R(f_j^{c2})$$

The formula shows the difference between the amount and activity of the pieces of both sides. It is far from accounting for all positional intricacies and peculiarities of the position. So it does not claim to be a final evaluation of the position. However, for our purposes, it works quite well. In order to enhance the given formula it is possible to limit ourselves only to the pieces included in the "*action zone*". [8]

3.3. Unexpected move

If we calculate the difference of position estimates made before and after the move (half move) then it will be possible to estimate the "*degree of expected move*" when the change is positive as follows:

$$\mu_E(t) = \frac{\Delta V_R(f,t) - \Delta V_R(f,t-1)}{V_N(Q)},$$

where $V_N(Q)$ is the nominal value of the most valuable piece, the queen. In other words, the maximal possible loss (purchase) for one move, will be

$\Delta V_R(f,t)$ – *M-P estimate of the position* after the move *t*.

The negative changes in this indicator can be considered as "*the degree of unexpectedness of the move*" and specified as follows: $\mu_{UE}(t)$

3.4. Beautiful mate

If we trace the value of the index $\mu_E(t)$ during the game, we can find the move t_{UE}, after which there was a sharp change in the value of unexpectedness indicator: $\mu_E(t)$. This corresponds to the "surprise" anticipation of the beauty.

If after few moves there will be a mate position on the board, i.e. position where the mate is inevitable, it would be concluded that there is a *"beautiful mate"*!

3.5. Linguistic variable "*beautiful mate*"

We can specify the linguistic variable "*beautiful mate*" with components: <β, U, T, G, M>

β = "*Beautiful mate*", U = [-2, 2], T = {"*beautiful mate*", "*ordinary mate*"}, G = {"*Not*", "*More or less*", "*Very*"}, M = {1 - μ, $\mu^{1/2}$, μ^2}

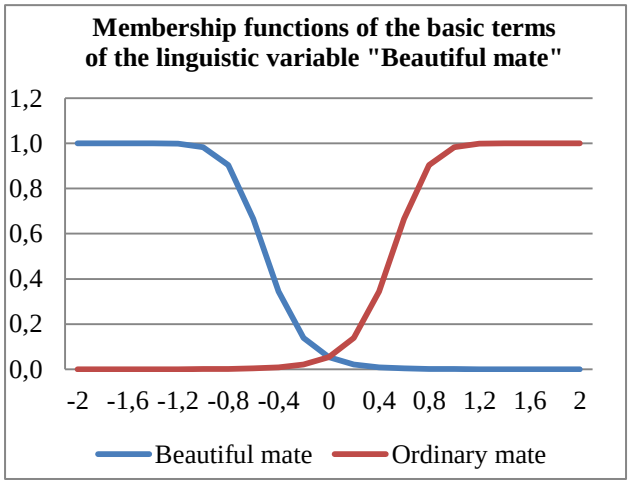
Membership functions of the basic terms are presented in the chart and have the following analytical form:

$$\mu_{tr}(u) = \frac{1}{1 + \left(\frac{|u-\alpha|}{\sigma}\right)^{\beta}}$$

where $tr \in T$ is an element of the Term-set,

α, β, σ are coefficients corresponding to each element of the Term-set,

$u = \sum_{t_{UE}}^{t_M} \mu_E(t) \in U$ is the sum of the degree of expectedness of moves after the unexpected move t_{UE} before the mate move t_M.



4. THE EXPERIMENTS

Let us illustrate the viability of the above models for the following chess positions.

4.1. Ordinary mate

In the given position, we can make an "*ordinary mate*" by the following sequence of moves:

1. ... K✕h1

The blacks made the *expected move* by increasing M-P estimate of the position to their advantage by increasing the material.

$\mu_E(1) = 0{,}589947$

2. ba Qc2

The whites made a quite *expected move* by increasing M-P estimate of the position in their favor, at the same time getting rid of the threat of direct mate.

The blacks, by their move, increased M-P estimate of the position in their favor by limiting the mobility of the opponent's king. $\mu_E(2) = 0{,}123457$

3. a4 Фc1#

The whites made a quite expected – the only possible move. The blacks checkmated.

Since $\mu_E(1) + \mu_E(2) = 0{,}713404$, then with certainty (= 0.9973) it can be described as an "*ordinary* mate".

4.2. Beautiful mate

However, in the given position a "beautiful mate" can also be made, although by a different sequence of moves:

1. ... Фb1+!!

The blacks made an *unexpected move* by decreasing the M-P estimate of the position in favor of the opponent by limiting the mobility of the queen, and under the threat (in fact, they are forced to accept the sacrifice of the whites) of losing the queen – the most valuable piece. $\mu_E(1) = -0{,}72143$

2. Л✕b1 ...

The whites made a quite expected (the only possible move) – as a result the M-P estimate of the position sharply increased in favor of the whites. According to the M-P estimate of the position, the whites have a huge advantage... But it turns out that by their next move the blacks put mate (in theory this is called "*smothered mate*").

2. ... Кc2#!!

Since we have a mate in 2 moves, then we consider the value of $\mu_E(1)$. For this parameter value, our belief that this sequence of moves can be described as "*beautiful mate*" is equal to 0.9976.

4.3. Comparison between computer and mans estimation of beautiful mate

We have tested the program for another 7 other positions also, which were checkmated by both beautiful and ordinary mates. In this case, five players – holders of the first grade, were interviewed for evaluation by the numerical scale (1 - 100) of beauty of these same 9 combinations leading to the mate end.

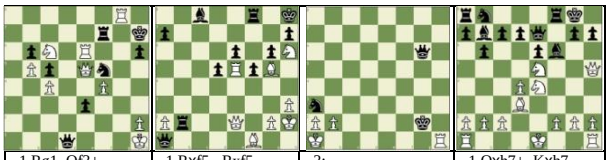
The results were compared as follows. We calculated the average values of each numerical score of beauty, given by these five chess players. The assessments made by the program were centupled. Then we have calculated a correlation coefficient (using EXEL program) of the two received number sequences.

Mate combinations / First grade chess players	A. Khojabaghyan	H. Markaryan	V. Gambaryan	T. Harutunyan	V. Vahradyan	Estimates of computer
1	85	60	75	77	75	77
2	95	85	90	85	90	95
3	60	40	60	30	5	3
4	80	90	70	60	90	71
5	100	95	90	80	95	100
6	100	80	70	80	60	54
7	80	65	75	50	75	59
8	100	95	80	80	95	97
9	90	90	95	80	95	99
Correlation coefficient	**0.96735**					

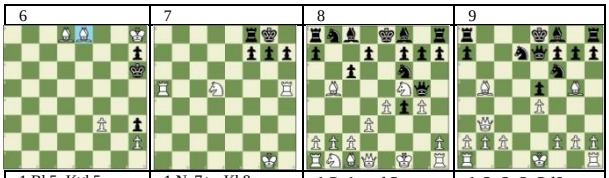
As can be seen from the table, a fairly high coefficient of correlation between the responses of the program and the average estimates of first grade chess players - 0.96735 is received.

The following are the initial positions and sequence of moves that led to the mate end.

1	2	3, 4	5



1.Rg1 Qf3+ 2.Rg2 Qf1+ 3.Rg1 Ng3+ 4.hxg3 Qh3#	1.Rxf5 Rxf5 2.Qe5+ Rxe5 3.Bf6#	3: 1.Kxh1 bxa3 2.Qc2 a4 3.Qc1# 4: 1.Qb1+ Rxb1 2.Nc2#	1.Qxh7+ Kxh7 2.Nxf6+ Kh6 3.Neg4+ Kg5 4.h4+ Kf4 5.g3+ Kf3 6.Be2+ Kg2 7.Rh2+ Kg1 8.Kd2#



6	7	8	9
1.Bh5 Kxh5 2.Kg7 h6 3.Kf6 Kh4 4.Kg6#	1.Ne7+ Kh8 2.Rxh7+ Kxh7 3.Rh5#	1.Rg1 cxb5 2.Qf3 Ng8 3.Bxf4 Qf6 4.Nc3 Bc5 5.Nd5 Qxb2 6.Bd6 Bxg1 7.e5 Qxa1+ 8.Ke2 Na6 9.Nxg7+ Kd8 10.Qf6+ Nxf6 11.Be7#	1.O-O-O Rd8 2.Rxd7 Rxd7 3.Rd1 Qe6 4.Bxd7+ Nxd7 5.Qb8+ Nxb8 6.Rd8#

5. CONCLUSION

To analyze chess concepts "beautiful mate", "unexpected move" and others the mathematical apparatus of fuzzy sets was applied and an acceptable correlation between computer and humans estimations of the "beautiful mate" for certain positions was demonstrated.

Experiments had demonstrated the viability of fuzzy theory in modeling complex human concepts.

At present we continue to develop fuzzy models for chess concepts focusing, particularly, on ones accumulated in the repository of chess vocabulary for about 300 concepts in [10].

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