The Limbic Characteristic and El-Farol Games

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Abstract: Human decision behaviour with there modelling has been an area of research for a number of years in many different disciplines. The idea of this paper is to model human characteristics in a computer based game environment (minority games). In order to prove our hypotheses of non rational behaviour decision in game theory, a simulation of the well known El-Farol game is introduced and analysed. The simulation results provided new and interesting results for our approach using the limbic characteristics for analysing the behaviour of players. The simulations proof that certain characteristic more successful than others.

1 Introduction and Motivation

In today saturated markets successful companies need to differentiate themselves from other companies. Success is more related to the customer than in the past and this can only be achieved by knowing and understanding the customer – and being fully aware of his/her behaviour and motives for making selections [BM07,HJ05].
Driven by the challenge of offering customers the right product and solutions, today, offerings to customers can be understood as well under the aspects of game theory [RC08]. Is it possible to identify different characteristics based on a marketing model for complex popular problem in economic systems battling for limiting resources without communications of attendee?
The prime question is: is it possible to identify which characteristic is more successful than another one? The limbic characteristic description uses the marketing approach to convert it into a computer agent model, which can be simulated, analyzed, discussed and compared against real life.

2 Characteristics and Minority Games

2.1 Limbic Characteristics

The limbic characteristics were introduced by Häusel in [HH07] and have the aim to systemize customer motives, emotions and values and to segment target groups for marketing purposes.

The central pillar of the limbic characteristic is modelling on three key motivational and emotional systems.
These three limbic instructions are:
- The **balance** instructions (wish for security, stability, warmth; avoidance of fear and uncertainty)
- The **dominance** instructions (wish for self-assertion, power, status, autonomy; avoidance of helplessness, heteronomy and oppression)
- The **stimulant** instructions (wish for variety, novelty and reward, avoidance of boredom and lack of stimuli)

Each person is been identified by the characteristics which are based on the limbic instruction (balance, dominance and stimulant). These 3 parameters values are defining the 8 main characteristics, presented in the following table, where as a 1 expresses in the instructions a relevance and 0 not relevance for this instruction.

Balance	*Dominance*	*Stimulant*	Characteristic Type	*Type No.*
0	0	0	*Apathetic person*	0
0	0	1	*Hedonist*	1
0	1	0	*Technocrat*	2
0	1	1	*Entrepreneur*	3
1	0	0	*Harmoniser / The scared person*	4
1	0	1	*Epicure / The Enjoyer*	5
1	1	0	*Stress-Type*	6
1	1	1	*Eccentric*	7

Table I: Limbic Characteristics

2.2 The Classical El-Farol

The El-Farol bar problem is created by Arthur [AB94] to investigate limited resource problems in economics see also [DW08]. It was inspired by the El-Farol bar in Santa Fe, New Mexico, which offered Irish music on Thursday nights. The problem is set out as follows: there is a finite population of people and every Thursday night all of them want to go to the El-Farol bar. However, the El-Farol bar is quite small, and it is not enjoyable to go there if it is too crowded. So much so, in fact that the following rules are in place:
- If less than 60% of the population goes to the bar, those who go have a more enjoyable evening at the bar than they would have had, had they stayed at home.
- If 60% or more of the population goes to the bar, those who go have a worse evening at the bar than they would have had, had they stayed at home.

Unfortunately, it is necessary for everyone to decide at the same time whether they will go to the bar or not. They cannot wait and see how many others go on a particular Thursday before deciding to go themselves on that Thursday.
Formally the El-Farol Problem uses N players where N (indexed by i) represents the inhabitants of the village.
Arthur mentions the use of a set of predictors in which each agent can select out of the portfolio his strategy, but the single characteristics were not part of the discussions. In several papers different strategies for predicators were been introduced [OJS06, ST06]

and discussed. The mathematical formalization of the set of predictors has been analyzed and discussed by Challet and Marsili [CD05]. Results has been achieved and presented but in a real life web experiment of a minority game it was discovered, that humans perform better than mathematical approaches. Which lead us to investigate further in this direction.

2.3 Modified El- Farol

The basic El-Farol game was modified in such a manner that it reflects the basic idea of the minority game. Where as minority games are been defined by the rule that the minority of the players are the winner in the game. The main idea was to model limited resources in a similar to stock exchange environment.
The next table represent the decision and the results for the modified El-Farol game. The table contains 3 players represent by the left column 0 and 1 for not visiting and visiting the bar. Where as the right side of the table represents the results of the decisions per player.

Player (1/2/3) ;0=Home,1=Bar	*Player 1*	*Player 2*	*Player3*
0 / 0 / 0	*0*	*0*	*0*
0 / 0 / 1	*-1*	*-1*	*+2*
0 / 1 / 0	*-1*	*+2*	*-1*
0 / 1 / 1	*+2*	*-1*	*-1*
1 / 0 / 0	*+2*	*-1*	*-1*
1 / 0 / 1	*-1*	*+2*	*-1*
1 / 1 / 0	*-1*	*-1*	*+2*
1 / 1 / 1	*0*	*0*	*0*

Table II: Modified El-Farol Results for 3 Players

The game which is played in the simulation can be described as follows: $N=(1..N)$ are the set of players where $i \in N$. The actions are $D = (0,+1)$ and describe the set of possible actions. Where 0 is **not to go** to the bar and 1 is the decision **to go** to the bar. Each simulation step is represented by t that is incremented after each simulation until it reaches the end. The conclusion is defined by the number of games and the rounds per each game. All players have an account which contains a starting value which is zero for every beginning of the game. For each game simulation step every player pays 1 game unit. The total sum of charges for the game unit is equal to N. Each player decides the actions for joining or leaving the bar. The players who choose the minority receive the payoff where as the players in the majority receive 0. Where L is number of players in the minority and K is the number of players in the majority. $N=L+K$. The payoff for each player in the minority is given by $Payoff\text{-}L_i=N/L$. The majority payoff is given by $Payoff\text{-}K_i=0$.
For the two cases in which no minority is been defined a) everybody goes to the bar b) nobody goes to the bar all players will get back there game charges of one unit.
The modifications do follow the rules of a zero sum game and can be named as zero sum minority game.

3 Simulation

3.1 Modeling of the Characteristics

As already discussed in section II the basic limbic instructions are been model in the simulation software as follows:

The **balance instruction** primarily describes the wish for stability and fear. This is mostly represented by the account value of the game. In order to make a decision the balance introduction is checking the account value if it is greater than zero or not. Afterwards due to the wish for stability it compares the software parameter of the basic orientations (to stay or to go). If the last n rounds were lost, the balance type changes his strategy compared to the previous used.
The **stimulant instruction** describes the wish for variety. If this value is 0 every decision is changed. If this value is 100 once made, a decision is kept. Another parameter in this configuration allows as well the definition of the degree of risk tolerance. This parameter is been used for the relation with other limbic instructions
The **dominant instruction** expresses self-assertion, power and status. The dominant function is calculated out of several prediction functions, which give the best probability for the win in the next round. These functions are

- Average of the n rounds of visitors
- Median of the last n rounds
- Cycle calculation of visitors over n rounds and
- Trend function of the last n rounds.

Based on this prediction functions an estimate is calculated as to which function would be the best. This information is used to build a profit margin afterwards and is used for the next selection criteria.
The decision logic is implemented in simulation Software as follows:

Type 0: This type does not follow any method. The type is deciding randomly
Type 1: This type use the decision method described in stimulant instruction
Type 2: This type use the decision method described in dominant instruction. Average/median/trend function last 4 to 7 rounds, Cycle last 2 to 5 rounds
Type 3: This type use the decision method described in dominant instruction with Average/median/trend function last 2 to 5 rounds, Cycle last 2 to 4 rounds and the stimulant combined with the wish of risk value
Type 4: This type use the decision method described in balance instruction.
Type 5: This type use the decision method described in balance and stimulant instruction and with the wish of balance weighted value.
Type 6: This type use the decision method described in dominant instruction with Average/median/trend function last 2 to 4 rounds, Cycle last 2 to 4 rounds and the balance combined with the wish of balance weighted value.
Type 7: This type uses the decision method described in dominant instruction with Average/median/trend function for the last 2 to 3 rounds, Cycle last 2 to 3 rounds and the balance + stimulant instruction. The decision to go to the bar will be made from the majority of results between the instructions.

3.2 Simulation Results

In order to compare the results of each game per characteristic the results are presented in a matrix in which every characteristic is played against any other characteristic. The entries in the matrix can contain two entries - win and undefined. Win is indicated as standard deviation distance to the other character, which is not overlapping.

Winning / Types	0	1	2	3	4	5	6	7	Wins	Percentage
0		N/A	0	0	0	0	0	0	6	21.43%
1			1	1	1	1	1	1	6	21.43%
2				3	4	5	6	7	0	0.00%
3					3	5	N/A	7	2	7.14%
4						5	6	7	1	3.57%
5							5	5	5	17.86%
6								N/A	2	7.14%
7									3	10.71%
Undefined									3	10.71%

Table III: Results of Winning Type Matrix

Summarizing this information suggests that characteristic Type 0 and characteristic Type 1 are dominating and successful in this game and simulation environment.
This result indicates a clear strategy for the simulation environment in the modified El-Farol game. Random behaviour representatives in Type 0 and stimulant behaviour representatives in Type 1 are the winners in the game. Where as Type 1 can be as well interpreted as a modified random player. Type 5 is a stimulant player who is driven by the account information (balance instruction). This means if the character is successful do not change by behaviour which is stimulant. Type 3 which also contains stimulant instruction is been controlled by the dominance instruction which stops the stimulant instruction with the overruling parameter (setting 65% overruling of dominance).

From this simulation results it is clear, that

- there is a significant between the characteristics playing the game and
- there is a strategy for players to win the game which is to play randomly.

It is also interesting that these results do not stand in contradiction to experiments in stock markets where monkeys or other random players frequently perform better than professional brokers and analysts [WR10].As well do not stand in contradiction to the theoretical results in game theories which point out through the NASH equilibrium that the mixed strategy is a successful strategy for this game setting.

4 Conclusions and Future Work

The motivation and assumption of this work is to understand and prove that humans are NOT deciding rational. We introduced a computer environment for playing the modified El-Farol game with limbic characteristics for the players and analyzed the results. We

have proved that some characters are in special situation consistently more successful than others. These results also give answers for a successful strategy, which is random behaviour.
It seems that our model may support more complex decision processes than before. The approach of using the limbic characteristics was implemented in a non-marketing area for the first time. The modelling and results of this kind of emotional characteristics is a valid and useful approach in the area of computer science.

Future works will include a more detailed discussion of game results of groups consisting of different and more complex player combinations. Namely we think about a simulation with a character distribution derived from the German population as it can be obtained from [BC08]. In addition, the result seems to be quiet interesting for deriving strategies for the stock market extending the previously published results in [WR10]. Last but not least, for weak real time systems with a learning or adaptive scheduling strategy our results may be also applicable. In general, it is intended to answer the question, which impact limbic characters may have on the area of resource scheduling in complex networks. Consequently, it must be considered, if limbic characters maybe detected form the behaviour of the users in front of a computer system (e.g. by measuring his keystrokes or mouse movements) instead of a long questionnaire.

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