Simulation of Agents with Emotions in a Game of Poker

Surender Harsha Battu (S4120310)
Bharath Kumar Musuadhi Rajan (S4065476)
Sai Krishna Reddy Thiyyagura (S3585085)
Hari Vidharth (S4031180)

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Abstract

Experiments on agents with emotions have been carried out on different scenarios and for various problems. Researchers have shown that agents with emotions have better decision making skills in a socially interactive scenario due to co-operation [BB01]. Instead of evaluating agents' behaviour in a social scenario, it was interesting to observe the behaviour of emotional agents when presented with a complex competitive task. For this experiment, we simulated a game of poker in order to analyse the performance of the agents in a complex task that requires analytical skills. We developed a framework of multiple emotional agents whose emotions are constructed based on the theory proposed Ortony et al. [AC98]. These agents were configured with four basic emotions each emotion was further defined by three attributes. For evaluation purpose, these agents were compared against a probabilistic agent. Based on the experimental results, it is seen that emotions do have a positive impact on agents. And depending on the strength and type of emotion we noticed that the impact on agent's performance is varied accordingly.

1 Introduction

The effect of emotions in intelligent agents had been questionable until Rosalin W. Picard had shown substantial evidence to emphasise the need of emotions in intelligent agents in her article "Affective Computing" [Pic95] . The theme of her article was to prove the effectiveness of emotions in agents to make complex decisions and assist humans. Ana L. C. Bazzan and Radael H. Bordini conducted an experiment in which the behaviour of the agents were analysed in a socially interactive scenario (IPD) [BB01]. They created a framework based on the OCC model proposed by and named after Ortony et al. (1988) [AC98]. The OCC Model is a technique that combines cognition and emotions for use in systems using formal language and rules. Their framework combined this psychological OCC model along with decision theory to make emotions readable. The framework that we have developed for our experiment involves representing the emotions based on the combination of three attributes with different strengths for each emotion which are further explained in below sections.

1.1 Problem

The research conducted on emotional agents in social scenarios gives us a perspective of agents' behavior as a group and also their outcome is of binary form, where in the result is positive if the agents co-operate and negative if the agents oppose each other. In reality, the agents that we build might not

necessarily be assigned to tasks that require social co-operation but those that require individual agent's decision making skills that results in better performance of the given task.

1.2 State of the art

The state of the art for this research is the publication from Ana L. C. Bazzan and Rafael H. Bordini - *A Framework for the Simulation of Agents with Emotions* [BB01], which paved us the way to build our framework of emotional multi-agents based on OCC model. Other publications that have inspired our project are *Affective Computing* by R. W. Picard [Pic95], which showed us the significance of the effect of emotions on computational agents and *Using decision theory to formalize emotions in multi-agent systems* by P. Gmytrasiewicz, C.L. Lisetti [GL00], which we had used to configure the emotional quotient of the agents.

1.3 New Idea

In order to understand the behavior of emotional agents in an environment other than social interaction with co-operation, we picked the game of poker which simulates a competitive multi-agent system where the performance of individual agent plays a vital role as it is evaluated against each other. The notion behind the selection of such a background is due to the fact that there exists different tasks in reality and the behavior of emotional agents in these environments have to be analysed. Also a game like Poker will allow us to make sure that the performance of the agents are quantifiable throughout the experiment.

2 Method and Implementation

2.1 The Game

The poker game that we have built for this experiment is a traditional Texas hold'em poker but the game is terminated after just one round. A traditional 52 card deck is used where each player gets two cards in his hand and there will be a total of five community cards by the end of the game.

2.2 Implementation

An Agent is a player in the environment, each agent has a hand of two cards, each agent starts with 1000 coins/points to place bets and each agent is given an emotion. This emotion is fixed and does not change throughout the game. Figure 1 shows the design of the model, with the environment and its communication with the agent. It shows a flowchart of the process which will be explained in the sections below.

2.2.1 Emotions

We use four basic emotions of humans, they are:
Fear, Happiness, Anger, Contempt
We also added two other agents: a no-emotion agent, a probabilistic agent that makes statistically optimal move and a default agent, this agent has default attributes which acts like a baseline.
Each emotion also has a power that determines how strong the emotion is affecting the agent and which is determined by a value between 0-1.
Here is an example agent with emotions and its power.

$PlayerID : 0, Emotion : happy, EmotionPower : 0.4835810757205069$
In the experiments each emotion is assigned randomly to players along with a random power.

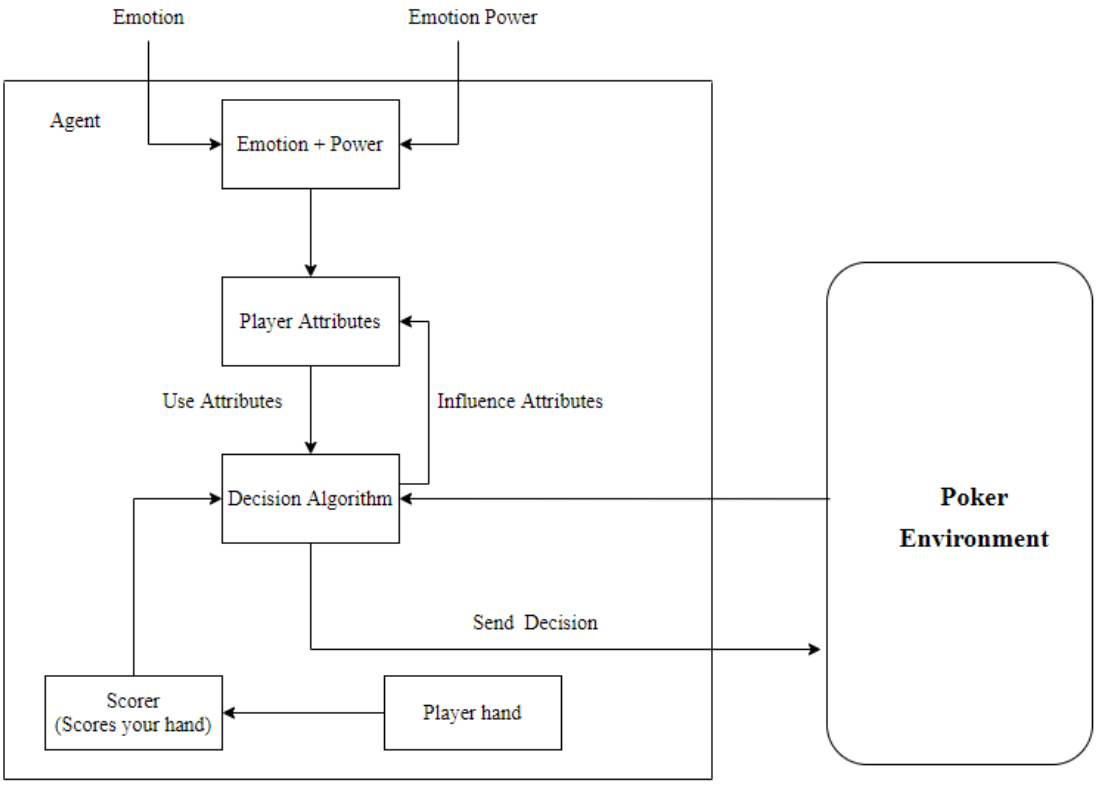

Figure 1: Model Design

2.2.2 Emotion Attributes

Each agent has a set of attributes that influences the decisions they take. The attributes we have defined are as follow,

- Caution
- Greed
- Bluff

Each attributes values lie between 0-100, with 50 being the default value.
Caution influences the player to make less risky moves. Even if the probability of winning is high, the agent may take a less risky move. The higher the value, the lesser the probability of taking a risky move(like raising a bet).
Greed influences the player to make risky moves despite being unsure of the probability of winning, this may actually result in a win if the agent gets lucky or it may result in severe losses.
Bluff is a special attribute, it influences the player to make riskier moves even when the winning probability is low to influence other agents to Fold.

Default attributes are Caution:50, Greed:50, Bluff:50. (Attributes of Default Agent). Emotions affect the starting attributes of each agent. Here are the formulae:
$IF\ emotion = Fear : caution = caution + Power * (50)\ AND\ greed = greed - Power * (50/2)$
$IF\ emotion = Contempt : caution = caution + Power * (50/2)\ AND\ greed = greed - Power * (50)$
$IF\ emotion = Happy : caution = caution - Power * (50/2)\ AND\ greed = greed + Power * (50/2)$
$AND\ bluff = bluff + Power * (50)$
$IF\ emotion = Anger : caution = caution - Power * (50)\ AND\ greed = greed + Power * (50)$
$AND\ bluff = bluff + Power * (50/2)$

As the game progresses, these attributes undergo very small changes based on the status of the game. But these changes are minor compared to the initialization done by the emotions.
Emotions do not change as the game progresses, but the attributes change which may affect decision making.

2.2.3 The Decision Making

Each agent has a few details at its disposal when making a decision each round.

During the game the hand cards, the coins available, the total coins in the pot and the hand score is available as information, each player then gives a score for each action.

Each action is given a score of occurring based on player attributes initially (only for emotional agents).

Then each agent adds upon on the score based on the coins in his hands, the bets placed, and the hand score.

The Decision making tends to vary based on emotions. For example the aggressive (Anger) player tends to place increased amounts of bets even though he has weaker cards, the scared player (Fear) tends to react by folding due to the high amounts of bets placed even though he has a better hand comparatively. Also as the number of coins a player has decreases, the probability to fold increases slightly. If the final score is high then the probability of greed and bluff increases, meaning that the chances for placing higher bet amounts and also placing bets with lower value cards increases.

2.3 Experiment Design

Even though the poker game was designed based on a classical game of poker/traditional Texas Hold em Poker game, the current experiment design is 1 Game of Poker = 1 Round of Poker, the winner of the round is the winner of one game of Poker. Every agent starts with 1000 coins/points from which he can place bets. For every round in the game every agent is forced to place a bet amount of minimum 10 coins which forces the player to participate instead of quitting. Using the above criteria and rules we designed a experiment to run 10000 simulations of the poker game. For each game the emotions and the strength of the emotions are randomized. Every new game or simulation the coins/points of every player is reset to the original amount. The winner is declared after every game by criteria of maximum coins/points at the end of the game.

3 Results

A total of 10000 simulations of poker games have been run, and on average, all emotions appear an equal amount of times (approximately 7500 games) as seen in Figure 2. The standard deviation of emotions on the number of games is around 50. Hence it can be asserted that in these random simulations, every emotion had an equal chance to perform.

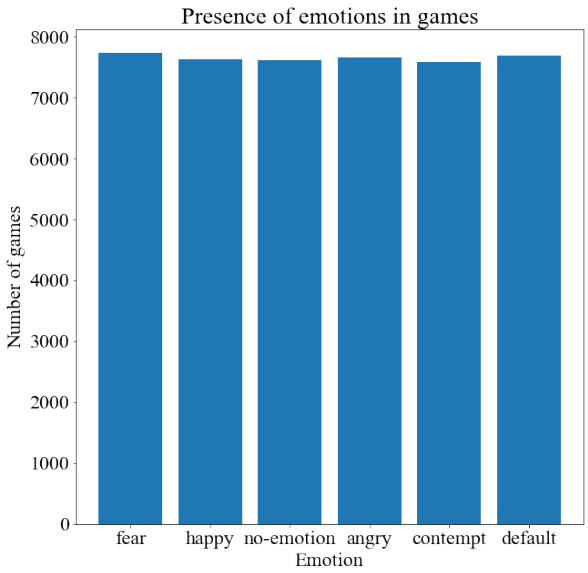

Figure 2: Number of Games each emotion appeared in

Figure 3 represents the Power of emotions when they win. This means that the strength of the emotions determines the performance of the player during the game. The player with anger as an emotion has the strength of aggressiveness close to 0.6 average and the player with fear as an emotion has the strength of fear close to 0.48 average when he won the game. The strength of the positive and negative emotions affect the performance of a player during the game in a directly proportional manner.

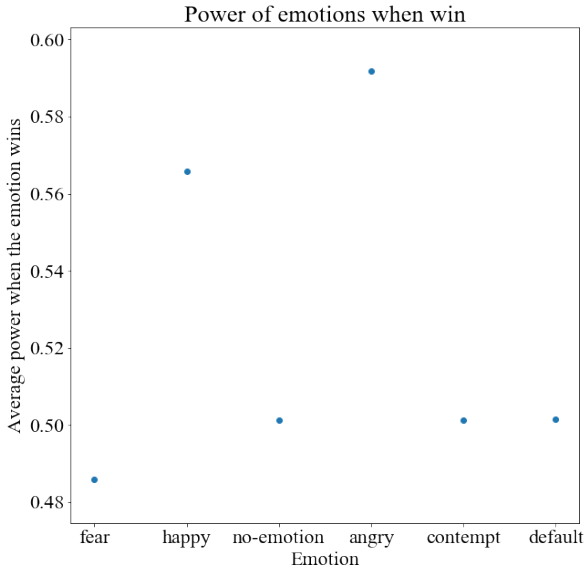

Figure 3: Strength of emotions for winning

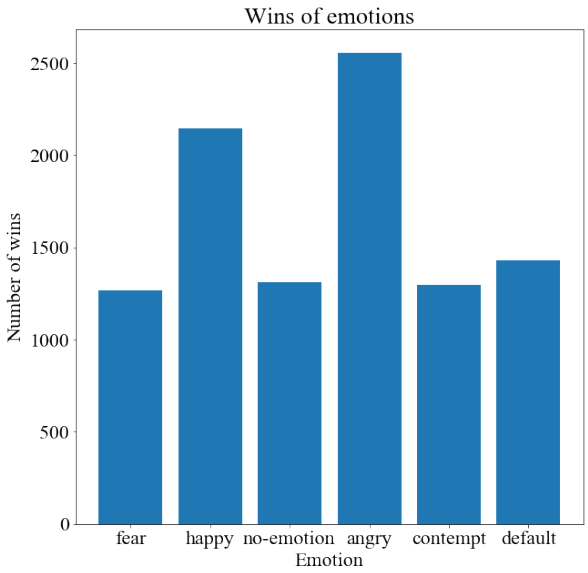

Figure 4: Emotional Agents Winnings

Figure 4 represents the average games won by each emotion, we observe that more aggressive and more happy players have the first and second place respectively and the remaining players with the remaining emotions are behind them accordingly. The more aggressive player seems to be the clear winner but it comes with price, a more calm opponent with a good hand can always triumph over an aggresive player. We will look at this in detail below.

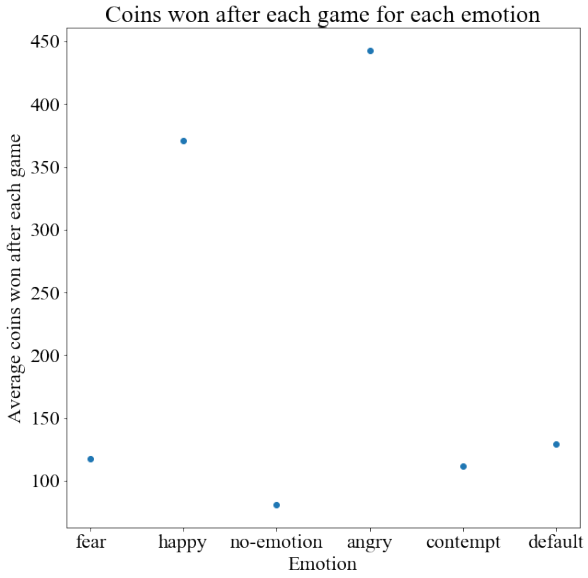

Figure 5: Amount won after every round for each emotion

Figure 5 shows the amount of coins won after each game. On average the aggressive player wins 400+ coins per game.

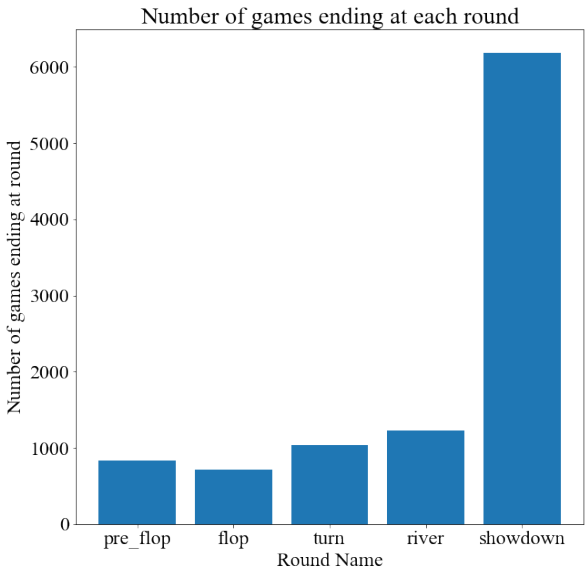

Figure 6: Games ending in which round

Figure 6 represents the number of games that ended in a showdown. This shows that the agents even though having different emotions and different attributes and different strengths of the emotions have played until the final round for most of the games. This highly depends on the forcing of bet placements during the initial rounds and the strength of the cards of each players combined with the community cards of each round respectively.
Take a look at the figure below,

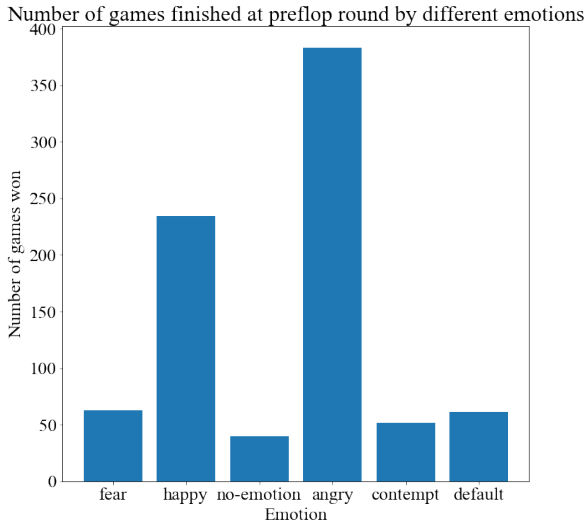

Figure 7: Emotions that won in PreFlop Round

According to Figure 7 we can see anger and happy ended most games in preflop round, this is because of the aggressive betting nature of these emotions. This holds true for Flop, Turn and River rounds. Because the only way other players lose these rounds is by folding. The other emotions and non emotion agents are intimidated into folding by the aggressive agents. The only way they can hold

out is if they have a high hand score.

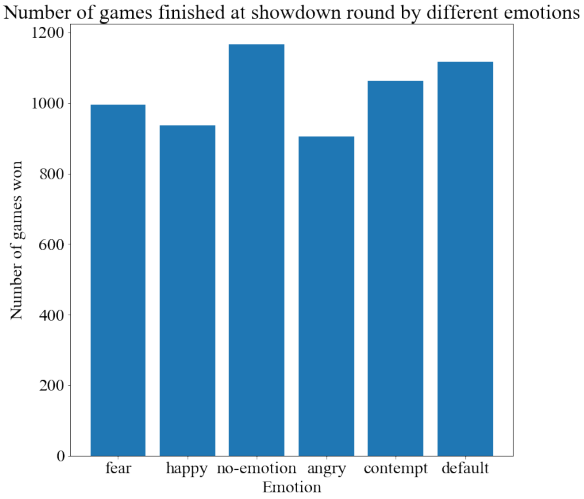

Figure 8: Emotions that won in Showdown Round

Figure 8 shows that anger and happy win lesser games in showdown than other emotions, this is because the other agents have held on without folding in the previous rounds, the reason could be because the bet amount was not very high or the other agents had good hands. No-emotion shows the highest wins at showdown because it doesn't take emotion into consideration, it only takes the hand score therefore enabling it to win most of the times.

4 Conclusion

The intention of this experiment was to observe, analyse and evaluate the performance of an emotional agent in a complicated analytical task so that we will have a general idea on how the implementation of emotions in agents will reflect in real-life scenarios. The results showed that agents with emotions did have improved performance over a probabilistic agent. Also from the above results, it can be seen that the different emotions had a different impact in the decision-making process of the agents and these variations in performance within different emotions are attributed towards their defining attribute strengths.

4.1 Discussion

In her article [Pic95], Picard had mentioned with evidence that emotions played a major role in decision-making, which acted as a foundation for years of research to come. When we set out to conduct this experiment, one of the basic emotions that we had picked to implement was 'anger'. Humans tend to make mistakes when they are angry. However, this was not true when it was implemented onto a probabilistic agent and when especially pitted against agents with other emotions. The agent with 'angry' emotion had in fact performed well in the experiment. And this could mean that these results cannot be interpreted in a literal way, i.e., agents having emotions like happiness or anger might not outperform fearful/contempt agents in reality, since in reality the actual task is different from the game and the actual emotions are different from the attributes we had used for defining the emotions. Also, it has to be noted that the results we have shown are from a simple implementation of emotions based

on the OCC model, which is one way of reflecting emotions onto agents. It would be interesting to see how the results would vary if this underlying model of the framework, which is the core of this experiment, is fine-tuned with a complex function. We had picked this model based on Bazzan and Bordini's arguments that it is one of the practically viable solution to computationally implement emotions [BB01]. But instead of experimenting emotional agents based on the OCC model, if the focus is switched on creating a model that would more accurately represent emotions in agents, then it would be beneficial in the research of emotional agents.

4.2 Relevance

In contrast to the experiments based on social emotional agents, we experimented the emotional agents in a non-social scenario as we felt it is vital to have research conducted in this area because of the existence of such tasks in real-life i.e., Complex analytical tasks, tasks involving random events, tasks with incomplete information or tasks involving a combination aforementioned tasks.

Though our results might not hold true for such tasks due to the aforementioned reasons in the discussion section, the necessity of experimenting with emotional agents on such scenarios seems inevitable.

a) Tasks involving random events:
Autonomous driving is one area where there's a considerable amount of research being carried out and yet the driving skills of the agents are not on par with human driving skills especially when a random event occurs. The implementation of such individually performing emotional agents could improve the decision making skills of agents when random events occur.

b) Tasks with missing / incomplete information:
One of the task where humans excel is art / creativity. In spite of having a pattern, due to the lack of a defined output, human decision making is still leaps ahead of intelligent agents. Could emotional agents break this barrier and perform better in art?

c) Combination of complex analytical task with random events and incomplete information:
The behavior of Non-Player Characters (NPC) in computer games have come a long way since its inception, thanks to the advent of Artificial Intelligence. There's still substantial difference between the behavior of an agent and that of a human. The advancement in the field of emotional agents should bring in significant progress and make the NPCs having close to human behavior.

5 Role of team members

Each member of the team actively participated in the initial literature review and the subsequent tasks. The table below shows an approximation of distribution of tasks among the team members.

Task	Bharath	Surender	Sai	Hari
Report	60%	20%	10%	10%
User Interface	10%	10%	60%	20%
Poker Game Implementation	10%	20%	10%	60%
Implementation of emotional bots	10%	60%	10%	20%

Table 1: Role of team members: Distribution of tasks in percentage

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