Modeling of Emotional-Social Negotiator Agents

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Abstract— Social intelligence is the ability of manage and improve one's relation with others which can lead to better joint performance in a group. Social intelligence can improve agents' interaction in a multi-agent system. Negotiation is a multi-agent system in which agents are cooperating to reach a joint agreement as well as gain more individual utility. This situation has great potential for conflict between social and individual goals. In this paper, in order to compromise to reach both social and individual goals, emotional-social agents are proposed to manage negotiation interactions. Experimental results show that emotional-social negotiator agents reach fair agreement, and also achieve more individual gain. Keywords: Social intelligence, Multi agent systems, Emotion, BDI architecture, Negotiation.

I. INTRODUCTION

In a negotiation process, agents try to reach a fair agreement by exchanging offers. A main part of negotiation is the decision to select the next offer. Although rationality has a key role on decision making, but recent researches have shown that it is necessary but not sufficient [1]. Negotiation can be considered as a collective process in which each agent try to achieve its own goals as well as a fairly agreement [2]. Agent with different goals lead to goal conflicts in negotiation [3]. Tisser *et. al.,* believe that in a negotiation process, agents cooperate to reduce these conflicts. Albrecht [4] stated that social intelligence can reduce conflict in a group. Hence, we are interested in modeling agents that utilize social intelligence features. Since emotions have important role in decision-making, we utilize it in a social situation. Recently, researches have stated that even we do not have human like agents, the effect of emotion in decision making process cannot be ignored [1]. In this paper, agents have BDI architecture. We try to enhance this architecture with emotional and social characteristics.

This paper is organized as follows: the next section is belonged to the background. In the third section the proposed model is discussed and finally in the fourth part, the experimental results are represented.

II. BACKGROUND

A. Social Intelligence

Social intelligence is the ability to manage one's relationship with others, which is primarily defined as a human skill [5]. In agent societies which members cooperate to reach collective and individual goals, utilization of social intelligence can lead to a better performance [6]. There is no real agreement on the concept of "social" and what social agents are. The most important features of social intelligence - based on the different definitions - are listed as follows:

- Understanding others' motives [7]
- Monitoring one's own and others' emotions [8]
- Being affected by others in a group [6]
- Having the ability to coordinate and adapt [9]
- Using social intelligence to guide one's thinking and action [8]

Among these features, emotional aspects attract less attention. Hence, we are interested to consider emotional aspects in social intelligence. Although usage of emotions in decision making process seems irrational, it has social and cognitive influences on rationality of intelligent systems [10].

B. Generic Emotional Agent (GEmA)

Emotion generation in agents is a key part in each emotion-based model. In this paper, since GEmA can be integrated easily into software agents as an individual module, we have utilized GEmA for emotion generation in agents. GEmA uses the Ortony, Clore, and Collins (OCC) model [12] for the elicitation of emotions by the appraisal of events and actions with respect to goals and standards. We used 4 of the 16 emotions that GEmA produces as outputs in Table 1.

TABLE I. SELECTED EMOTIONS FROM GEMA'S OUTPUT

Emotion type	Eliciting conditions
Satisfaction	**Confirmation** of the prospect of a desirable **event**
Disappointment	**Disconfirmation** of the prospect of a desirable **event**
Relief	**Disconfirmation** of the prospect of an undesirable **event**
Fear-confirmed	**Confirmation** of the prospect of an undesirable **event**

III. PROPOSED ARCHITECTURE

We have built our model a top BDI architecture. The model incorporate BDI architecture with social intelligence features.

Firstly, the main characteristics of a socially intelligent agent should be defined. There are various features for social intelligence suitable for social actions of agents, social commitment, take in to account others, etc. To develop a social agent, the BDI architecture has been considered as a

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basic architecture and the desired social features has been adopted. More explanations about the sociality requirements are mentioned as follow.

A. Social action

A social intelligent agent is expected to do social action. A social action is selected based on the social reasoning. Social reasoning is the capability of induction about the others' mental state [13]. We have used emotions to indicate the internal state of an agent. We assumed that the others' emotions can be received as a social percept, and agent uses this perception in decision making process. Satisfaction is used as one of the most important emotions in a social context [14], hence we focus on this emotion to describe others. In the other words, the other's emotional state limit to their satisfaction.

The other desirable feature is social commitment. It represents the effect of agent's action on an agent society [13]. Considering others mental state lead to both social action and social commitment. The basic question is how this feature can be modeled exactly.

B. Social goal

Conte [13] believes that a social agent should have some social believes in its' built-in motivations. Motivations refers to the agent's wishes [15]. We mapped motivation into desire element of BDI model. Hence, the agent must have a social goal in addition to individual goals. What is a social goal exactly? In one viewpoint, social goal is the group goal that all agents try to achieve. In another viewpoint, it is considered as a goal referred to others' mind [13]. Mind is a cognitive regulatory consists of belief and goals [16]. Hence, we have considered social goal as both common goals and cognitive goals.

C. Social agent

The overall architecture of proposed agent is illustrated in Fig 1. The perceptions include the others' satisfaction about the social situation.

In the belief revision function, percepts may change agent information about the environment. In this model, the emotional state of agents can be influence indirectly by percepts through Belief element. For example if a party agent's satisfaction changes into low after occurrence of an event, negotiator's emotional state is changed based on desirability of the event.

Others' emotion which is received as social percepts changes agent's social beliefs. Social beliefs are about others' mind and can influence social goals in current desires. In this paper, the "generate option" element in standard BDI model is ignored and we have considered predefined goals for agents.

Both social goal (common goals or cognitive goals) and individual goals are organized hierarchically with the various priorities. The filter element refines desires into intentions. Three factors have the key role at filter element:

- belief
- desire
- emotion

In other words, agents' options, beliefs about the world and other agents, and current emotional state are important factors in filter elements. These factors are effective to select an option as an intention. GEmA architecture evaluates the intensity of emotions based on percepts and also the current intention.

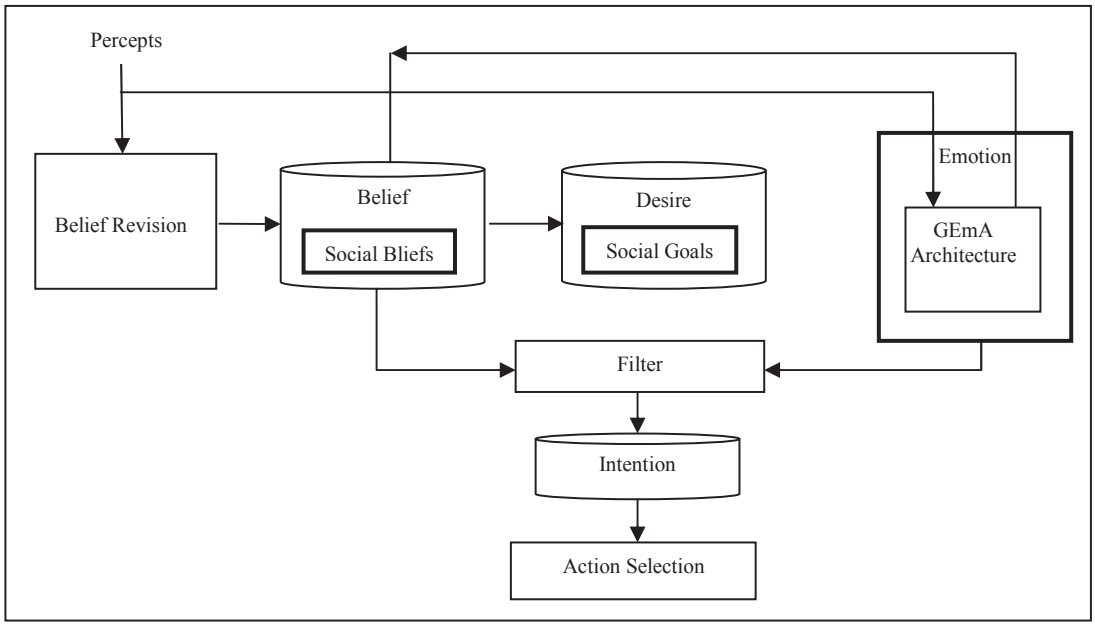

Figure 1. Emotional-Social Agent (ESA)

IV. SOCIAL AGENTS IN NEGOTION

Negotiation is a collective process in which agents' interactions play an important role, hence, more effective interactions lead to better negotiation results [17]. We have implemented a negotiation environment in which two Emotional-Social Agent (ESA) are negotiate about some hypothetical issues. In a negotiation process, agents have preferences that try to reach them during the negotiation process. Each negotiator has a hierarchy of goals with predefined priorities. Whenever an agent try to send an offer to the counterpart, a decision making process creates the best offer based on the agent's emotional state, preferences, and belief about others desirability by considering its own goals. In this case, ESA has social beliefs, social goals and also emotional element for social decision making. Social belief contains belief about others' satisfaction about the process. Social goals divide to group goals i.e., reach to fair agreement, and others goals i.e. increase others satisfaction.

As previously mentioned, percepts consist of the effect of agent's action in the form of counterpart satisfaction. In this paper, we assumed that agents send themselves satisfaction in fuzzy values form to others and they are honest. Hence, each agent has a level of knowledge about effects of their actions and uses this knowledge to update their emotional state and for decision making. In addition to actions, agent's emotions are effective in decision making. As previously mentioned satisfaction is sent to others as the current emotional state of an agent. But for more accurate evaluation three more emotions are considered to demonstrate agent's emotional state. Those are: disappointment, relief, fear-confirmed.

Whenever an agent sends an offer, it updates its emotional state based on how much agent achieves its goals by this offer. Whenever the agent receives an offer from another agent, the offer updates the agent's emotions as well. For selection of the next action, agents have four choices: accept, reject, create a new offer, or send a counteroffer. To select among these choices, the agent uses the following decision making algorithm:

```
If(selfSatisfaction=high){
   If (otherSatisfaction=high)
      Continue;
   If(otherSatisfaction= medium)
      Smooth tradeoff to others social goals;
   If(otherSatisfaction= low)
     Quick tradeoff to social goals;
}

If(selfSatisfaction=medium){
   If (otherSatisfaction=high)
      If(self fear-confirmed|| disappointment = low)
        Continue toward agent goals;
      Else
        Continue;
 If(otherSatisfaction= medium)
      If (self fear-confirmed || disappointment = low)
         Continue toward agent goals;
         //lead to better other satisfaction in next round
      Else
         Continue;
   If(otherSatisfaction= low)
      Smooth tradeoff to social goals;
      // lead to better self satisfaction in next round
}

If(selfSatisfaction=low){
   If (otherSatisfaction=high)
      If(relief= high|| medium)
         Quick tradeoff to social goals;
      Else
         Smooth tradeoff to self goals;
   If(otherSatisfaction= medium)
      Smooth tradeoff to self goals;
   If(otherSatisfaction= low)
      If(relief= high|| medium)
         Quick tradeoff to social goals;
      else
         maybe you need to change the way to increase your
satisfaction;
}
```

In this algorithm, "selfSatisfaction" indicates satisfaction of negotiator about negotiation process and "otherSatisfaction" indicates party satisfaction. There are four choices based on this two factor: accept the offer, reject the offer, create new offer, and create a counter-offer. The phrase "Smooth tradeoff" implies an offer with a similar utility to the previous one. In this situation agents should prepare an offer with the minimal difference compared to the former offer. According to the algorithm, it can be the previous sent offer or the last received one. While phrase "Quick tradeoff" represents the next offer with large difference compared to previous offer. Based on the satisfaction in each situation, smooth tradeoff or quick one can be selected.

V. EXPERIMENTAL RESULTS

The Emotional-Social Agent (ESA) is implemented in JADE framework[1]. To evaluate the efficiency of the ESA, it has been compared with tree kinds of agent: ZI [19], ABMP [20] and Bayesian [21]. ZI uses a strategy which searches the negotiation space randomly without consideration of its own preferences or others [19]. ABMP uses a concession-based strategy which selects the next action based on itself preferences [20]. Finally Bayesian uses a Bayesian-based strategy which can learn about counterpart preferences [22]. These three kinds of agent cover a wide range of negotiation strategies. ZI is an example of strategies in which agents do not consider preferences. ABMP is an example of strategies in which agents consider themselves preferences only. Finally Bayesian is an example of learning strategies in which

[1] It is a java-based agent communication language (ACL) that provides massage passing and the other requirements for agent communications.

agents consider both themselves and counterpart preferences.

What are the important criteria for evaluation of a negotiation strategy? Koen et al., [23] argues that criteria are divided into two main classes: process-oriented and outcome-oriented. Process-oriented criteria include cost effectiveness which means how many steps are required to reach agreement? On the other side outcome-oriented is based on three criteria:

- Success: is an agreement reached?
- Efficiency: is an agreement Pareto optimal?
- Fairness: is an agreement close to Nash point?

Fairness is a key concept in social context [24]; hence in this paper we focus on the fairness which means the closeness to Nash point. We have used data of Genius [25] included agents and negotiation profiles. Genius is developed for international Automated Negotiating Agents Competition (ANAC). It is a useful tool that facilities research in the bilateral negotiations area. For evaluation, two ESA are negotiating on some hypothetical issues and their reached agreement is compared with other agents from Genius repository.

The results show that ESA reaches a fairer agreement with lower number of offer exchanges. Agents negotiated on six standard profile proposed by Hindriks *et al.* [25]. Negotiation results are shown in Fig 2.

In this figure the utility of agreement for both parties has been compared to Nash point. A Nash point is an agreement in which the utility of both agents is maximal [25]. Euclidean distance to Nash point is considered to measure agreement distance to Nash.

$$agreement =< U_n, U_p >, Nash =< U_{nNash}, U_{pNash} >$$

$$Distance = \sqrt{(U_n - U_{nNash})^2 + (U_p - U_{pNash})^2}$$

Where: $\boldsymbol{U_n}$ *is the utility of agreement for agent and* $\boldsymbol{U_p}$ *is the utility for party.* $\boldsymbol{U_{nNash}}$ *is the maximum utility for the negotiator and* $\boldsymbol{U_{pNash}}$ *is the maximum utility for party.*

Experimental results show that in compared with Bayesian, ZI and ABMP, the utility of reached agreement for ESA has less distance to Nash point in more than 83% of tests. It means that ESA obtain fairer and more acceptable agreement.

VI. CONLUSION

In this study, architecture of an Emotional-Social Agent (ESA) was discussed. The main features of ESA are social reasoning, social action and social commitment. These features improve social behaviors of agents as well as individual and group performance. The ESA has been evaluated in a multi-agent system as a negotiator agent. Experimental results show that ESA reaches an agreement with more utility for both participants.

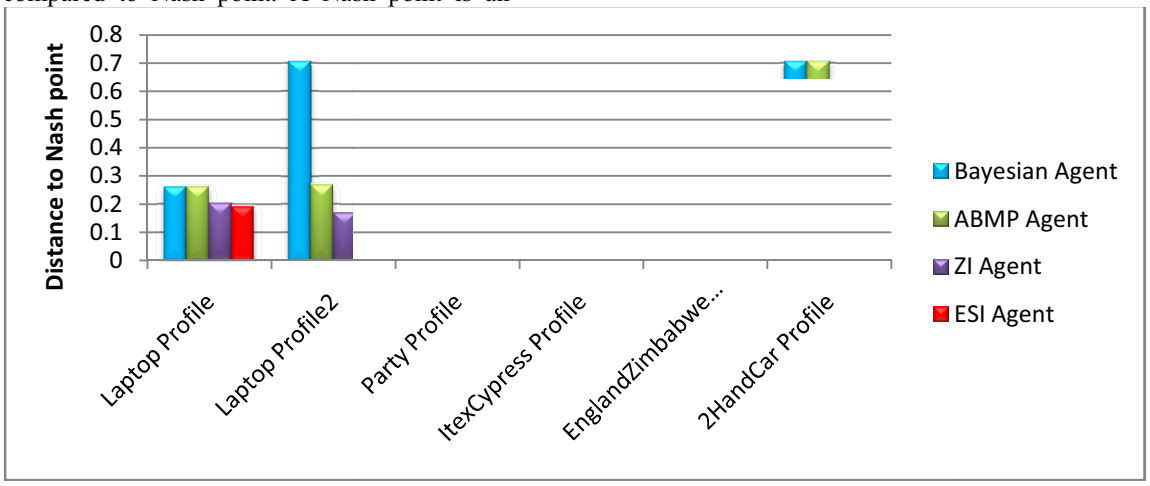

Figure 2. Comparison of ESA, ZI, ABMP, and Bayesian with respect to distance of reached agreement utility to Nash point

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