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EMOTIONAL MODELING FOR INTELLIGENT-AGENTS IN PROCESS INDUSTRY

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Abstract

Intelligent agents are the upcoming frontiers of research in process industry specially in taking managerial decisions. Agents are tasked to work in societies with other artificial peers in modes like collaborating, cooperating, and competing in order to defend their own goals and achieving them while maintaining their existence and interactions in the society. The management of resources in process industry, relationship building for collaboration with friendly or competing against rival competitors, maintaining proactive behavior within the society and innovation to discover new more effective ways to achieve their goals are pressing issues. These are computational expensive tasks. There is a dire need to optimize the working model of the agents to make them more autonomous and intelligent in a broader social prospective. Many models of mapping human emotions in agents are available these, however, do not state how to improve the productivity of the agents. In this paper, we present a model of agents in which human emotions are mapped for agent communication and interactions. The emotions for this stage like joy, despair, envy, adventure motivation, and fear are implemented quantitatively. These emotions are employed to increase the productivity, proactive behavior, and make agents more autonomous and intelligent. It removes the over head of managing and running separate services for management of resources in process industry.

Keywords: Emotional Model; Human Emotions; Intelligent Agents; Process Industry

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1. Introduction

Intelligent agents are unique as these entities are working to perform their own goal or task which may be conflicting from other entities in society unlike concurrent systems that are all delegated to perform the same task like completion of a product. As a part of a society of agents where they need to interact with other agents, there is need for negotiating some trade off agreement in order to collaborate on common goals, or reaching some agreement on conflicting goals. This puts a lot of constraints on agents working under many limitations and laws that are imposed by the society. All resources and environmental factor are not in control of any one agent. As a member of society, it has to follow the rules just like state laws human abide by yet strive to maximize its success. Emotions and internal feeling often motivate humans to perform several actions that cannot be strictly defined by logic. These actions being adventurous increase their success rate.

Emotional states of humans cause them to react differently under same state of environment, or event for example success in collaboration or suffering a loss in a risky attempt. A common assumption was that emotions are not productive, and logic alone in a rational mind is the reason for intelligence. More logical and less emotional person was assumed to be more superior; however, emotions are both cognitive and non cognitive intelligent behaviours as a result of millions of years of evolution. This is called Emotional Intelligence (EI) that has pivotal role in success at work environment [11]. EI also serve to fair share in survival and sociability of an individual. Experiments have shown the losing connection with emotions leads individual to become a misfit in a society [10].

Absence of emotions makes the action set stagnant after some time. Using the classical approaches of Artificial Intelligence (AI), event-action rules would fire the same action for an event or state of environment. This approach may seem flawless but there is no flexibility towards optimization. As the utility value may not be the same for the agent over a long period of time. There is no action ever taken with risky outcomes just like adventure motivation in humans. For instance, risking an investment or try a new ice cream flavour is even after achieving a high success ratio or having enough resources to experiment. This suppresses the element of innovation and discovery towards actions that are not predefined which may help agents to perform task with higher efficiency and productivity. To make the agent more efficient we merge EI with AI. This gives the agent ability to experience emotions qualitatively. As an outcome, an agent can adopt the actions selected not only on the state of environment but also on the personal emotional states. This approach provides room for innovation and adaptability. But the problem with OCC model[6] model named after the authors Ortony, A., Clore, Gerald, Collin, remains persistent as there is no measurement of how much an emotion is experienced. For example, how pleased an agent is with its success. In order to ensure the emotions to be intelligently aid in decision making it's of prime importance that they are quantified.

The experience and expression of all emotions is also affected by the social status of agent and its own unique behaviour. In the nut shell humanoid emotions drastically improve the performance of agents in a society as it gains motivation to be more proactive on individual level, innovate and helps develop relationships. Having no model of emotions implemented the agents lack the ability to adopt the environment. As every emotion is result of millions of years or evolution. OCC model must however have the utility of not only qualitatively exhibit emotions. A quantitative experience and measurement is also required to implement the reactions more precisely and to maximize the potential gains of emotion implementation over a long run.

Any industry running a process may need to collaborate with other vendors for services or product. The negotiations between the competing options cannot always be done based on mathematical rules. We are more prone to trust partners that we have a history of good experiences and we tend to avoid partners that have miss committed or have violated terms of a commitment. EIPSA follow the same model of human nature resolving and negotiation issues on base of natural selection. As agents are also continuously reacting with the environment they also need a dynamic and novel method of sharing. That provides more productive outcomes on a global prospective for agent society with mutual success.

Instead of developing an interaction model of society based only on mathematical rules, we propose the emotion model. Merging artificial intelligence with EI, we make a new generation of intelligent agents. Actions taken by agents will not be only decided by the set of hard coded rules, but also on its present emotional state. The emotional state does not only effect the agent individual states and processing, but also affects the interaction at social level i.e., the behaviour during the interaction with other agents. The rest of the paper is as follows Section 2 discusses the related work. Section 3 gives the architecture of the proposed agent for process industry to help decision making. The case studies are explained Section 4. The conclusion of the paper is given in Section 5.

2. Related Work

There have been many efforts to map human emotions using models primarily for computer applications and humanoid robotics. The most influential model given was the OCC[6] model. It views our working characterization emotions as valence reactions to events, agents, or objects, with their particular nature being determined by the way in which the eliciting situation is constructed [7]. Emotions are categorized on basis on action of agents, consequence of events and aspect of objects. A qualitative analysis of OCC model, specifying the conditions for when an emotion is experienced [12].These emotions are evaluated under two criteria arousal/appraisal and activation/valence, representing which emotions and how much are they felt quantitatively. Emotions are characterized as desirable and undesirable, as positive or negative. We argue that emotions are desirable as they help to agents to get enhanced performance, if mapped on every agent present in society.

Social status also affects expression of emotions. Some of our behaviors are amplified, and others are inhibited in the presence of some superiors or employees. Multiagent System (MAS) society cannot ignore the importance of this behavior adaptation [8]. Emotions are also implemented using fuzzy logic by for human-agent communication we intend to use it for agent-agent interaction.

Elliott's Affective Reasoner (AR) [9] was a MAS system implements in with agents had the ability to analyze the environment and the variants to decide which reasoning and emotion has to be triggered. Reilly and Bates's Em system in Oz project [10], they made the emotional module for the Oz world which nullified the effect of emotions over time and ensured that some interaction was made to activity persist the emotional state. There have been more attempts to improve the OCC model as in [1] that utilizes fear and hope in cases where the outcomes of events is not predictable or is unsure . Another attempt to improve the model was given by [12] to more streamline the model removing the ambiguities from the model.

The models stated above concentrate on the modeling and representation of emotions in intelligent agents. However, we implement these emotions in a way to get better agent performance and lesser over head for management. Also, agents are more autonomous, empowering agents with emotions enables them to be more intelligent and productive.

3. Emotionally Intelligent Proactive Social Agents (EIPSA)

Resource allocation and revocation a mediator can perform for small society of agents; it is practical but becomes more computationally expensive when the number of the society grows, until it becomes impractical. Besides agents society designed based on these rules may achieve these goals for a certain threshold, but after that ultimately the pool of actions becomes stagnant and recursive. Such situation stops the discovery and innovation processes, which require motivation, derived from emotions.

How do emotions influence agents? It is as follows:

a. Joy
b. Despair
c. Envy
d. Liking\Affection
e. Dislike\Hatred
f. Fear
g. Adventure Motivation.

The implementation details of these emotions along with their role in decision making is given in later in this section with their respective layers they are implemented in as shown in Table 1. It gives the emotions along with both polarities that ensure the equilibrium in the system and their magnitudes affect the decision of the agent. The layers of planning on which the emotions are mapped are also given in the table. In order to implement the emotional model of an individual agent, firstly Inte RRaP [13] model is selected for this goal, as it is one of the common models for agents implementation. InteRRaP model has a layered architecture that provides utility of separation of cognitive and non-cognitive emotions. This is the base for our Emotionally Intelligent Proactive Social Agents (EIPSA) (see Figure 2).

As in real life all our interaction with other people is not uniform and even our emotions

TABLE I
EMOTIONS AND THEIR COUNTER EFFECT EMOTIONS

Layer	Emotion	Counter Polarity Emotion
Reactive	Joy	Despair
Local Planning	Adventure Motivation	Fear
Social Planning	Liking/affection	Disliking/hatred
	Envy	NA

for other people are influenced by status of people we are dealing with. The same can be implemented for agents to increase their adaptability. Coupled with the fact our tendency to be affected by emotions is not uniform, so in our agent model, all agents could have different experience of emotions for same event. Also the effect of most emotions tends to get reduced and some event must trigger them again, this is so that the effect of an emotional state does not last indefinitely as in the case of humans. Humans also recover from a tragic loss after some times as the effect of good news or success is also nullified after some time.

Each EIPSA layer sends some abstractions Д to the above layer and sends directives Д to the layer below. The abstraction layer only contains the relevant information to the higher layers and also encompasses recommended actions against the currently perceived state. These directives Д remain the chosen course of actions unless overridden by the higher layer in the directives that are passed down. The directives decide the actions that are taken by the agent, and expression module in the low635241ermost layer to express emotions. The directives of the higher layer have higher precedence over the lower ones for the action and expression module. Precedence is as follows as shown in Figure 2:

Reactive layer < Local Planning < Social Layer

The social planning layer has the highest precedence and can override the action selected by layers below it. EIPSA has a matrix of emotions maintained for each agent. Quantitative increments and decrements are made as a result of each perception to their present emotional states. All emotions are mapped into a range of bounded real numbers for each layer. The agent when initialized is in neutral state with its internal states of emotions and also their relations with all other agents are neutral. All emotions are paired, with the exception of Envy. The triggering of any of these emotions causes the value to slide in their direction by some values depending on conditions. Values of emotions that are experienced are also affected by the unique multiplier of individual agent. All agents feel a particular event differently just like humans. Event, like birth of sibling may have different levels of joy for different individuals. So a unique experience multiplier is multiplied to value calculated before it's added or subtracted from the current value. Any emotional state cannot be endured forever; timer is associated with each emotion that tends to move the current emotional state a neutral state.

We have implemented basic emotions like joy, despair, affection, loathing, adventure motivation, and fear. They are used in such a way that they balance out the affect of each other through behaviour inhibition system (BIS). BIS are natural counter measures for inhibiting a particular emotion from taking over all logic and the ability to make rational decisions. There is not determination of how to quantitatively define the emotional intensity. However, emotions are not uniformly experienced, and different individuals experience it with different intensity.

All the emotions mapped on the agent are balanced by another emotion that maintains equilibrium. For example success causes joy, moving the experience state towards positive value of Joy from a neutral state. In case if the agent suffers multiple losses it will reduce joy till its neutral. If further losses are suffered, then the same slider moves towards negative value of joy or despair. This makes our agent design emotionally balanced, i.e., a Behaviour Inhibition System is present from all emotions. For example, if an agent gets a certain level success from interactions it experiences joy making it more friendly and prone to share more of its resources. This continues until it meets successive

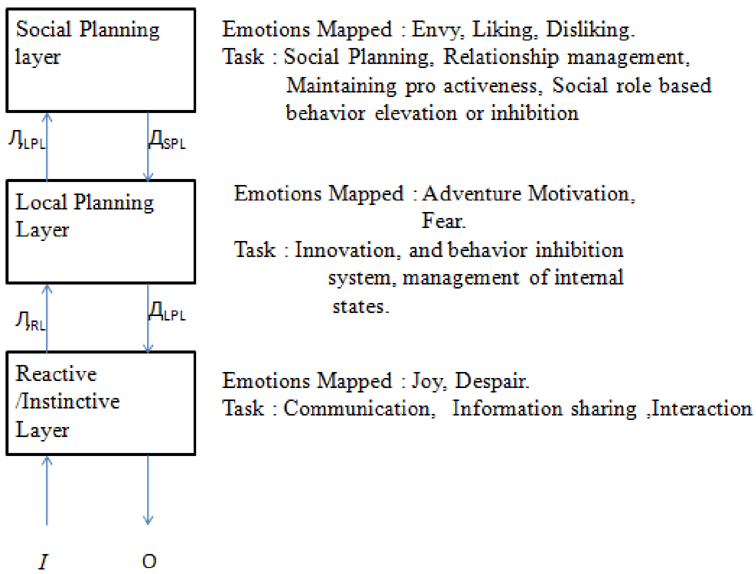
failure due to excessive sharing of its resources making the emotion of despair to kick in and inhibit it from further sharing. Possible denying further similar requests, depends on the quantitative value of despair.
Similarly adventure motivation is inhibited by fear. Liking/affection is inhibited by Dislike/hatred. Envy does not require an inhibition, as lack of resources for showing more proactive behaviour, automatically suppress it when it becomes impractical. These emotions are not only qualitatively measured but are also in terms of quantitative affect on behaviour, temporally. This means that a specific measurable amount of emotion affects the agent behaviour also for a specific time after which the intensity of emotion decreases [4]. This is derived from the fact that mathematical equations and numbers to express the human emotional states are used in [5].

Figure 1: The layered model of EIPSA

When an agent launched into the environment and starts to interact with the environment the agents is emotionally neutral means all layers have all their emotion on equilibrium neutral or calm state i.e. agent is neither in joy nor in despair.
EIPSA has three primary layers explained next:

3.1. Instinctive Layer

It is responsible for taking the environment perception and requests from other agents. This layer also provides the utility to share information about the agents current status which may include the resources held by the agent and the success or failure rate of the agent. These parameters are used by other agents to estimate the possibility of resource sharing or collaborating. Joy and Despair emotions are mapped on this layer. The former is triggered when the agent accomplishes a task or goal. The agent expresses higher agreeableness to share its resources. By contrast, Despair is triggered when agent fails to accomplish a task or goal. This leads it to become less willing to share its resources and



more greedy, asking other agents for resources. The triggering mechanism and current emotional state is saved in the rule base 1. The layer architecture is shown in Figure 3.

Use After taking the perception from the environment Belief, Desire, Intention (BDI) update is done by the reactive planner. This layer performs analysis of current event and decides if it was success or failure. Based on this analysis it calculates the amount of Joy or Despair experienced by the agent, sending the perceived data to the Local planning layer as abstractions ЏRL. The perception "I" is taken from the environment by the perception/Request module. Agent needs to judge when the current request or environmental state contributes to success or failure to one or many of its sub goals and its global success. Agent uses "Judge Current Env State/Request" rule with function update emotion that is first quantified making a relative increment to success quantifier and the personal sensitivity multiplier called Pmultiplier that is unique for all agents depending on their personal characteristics. This rule insures that agent has only one of the set of the emotional states {*Joy, Neutral or Despair}*.

Start Rule "Judge Current Env State/Request"
If percept (*I*) = "Success"
/*state environment or consequence brings successful */
Then
Emotion Q (I) <= Quantifier(Success (*I*))
/* Quantify the Success */
Updt Emotion (Reactive-Joy) (Pmultiplier x Emotion Q)
Increment (Reactive-Joy)
/* update the agent emotional state */
Update Emotion (Reactive-Despair) (Pmultiplier x Emotion Q)
Decrement (Reactive-Despair) /* update the emotional state of agent*/
Else If percept (*I*) ="Failure\loss"/* Environmental state or consequence is brings agent to a failure or loss */
Then
Emotion Q = Quantifier (Failure\loss (*I*)) /* Quantify the Failure\loss */
Update Emotion (Reactive-Despair) (Pmultiplier x Emotion Q)
Increment (Reactive-Despair) /* update the emotional state of agent*/
Update Emotion (Reactive-Joy) (Pmultiplier x Emotion Q) **Decrement** (Reactive-Joy) /* update the emotional state of agent*/
End Rule

As they are strictly personal emotions because they are dependant only on the personal success rate irrespective of performance of other agents. These emotions however, cannot be allowed to persist forever as continued state of joy makes the agent reckless and persisting despair discourages it from recovering from shock of loss. In order to make these emotions temporal and making them decay after interval of time bringing the agent to neutral emotional state this is done "DecayEmotion" Rule which is as follows:

StartRule "DecayEmotion"
If DecayEmotionTimer (*Reactive layer*) ="Expired"/* Check if the decay timer has expired*/
Then
EmotionalState Sense(*Reactive layer)*
UpdateEmotion (EmotionalState) **Decrement** (Reactive-Joy) **OR** (Reactive-Despair) /* Move Emotional state to neutral */

Decay Emotion Timer Reset Timer/* reset timer for decay*/
EndRule

This layer takes its directives from the layer in top of it i.e. the Local Planning layer affects the actions that are taken by reactive layer by sending it directives $Д_{LPL}$ as recommended actions for the scenario the reactive layer perceived and also the current emotional states that are mapped on the reactive layer. It receives the action directive from Local planning layer in basis of which it updates its emotions that are expressed to other agents and selects the actions that are to be performed against the new environmental state that was perceived by the action and Expression module, along with the directives to advertise of the emotional states.

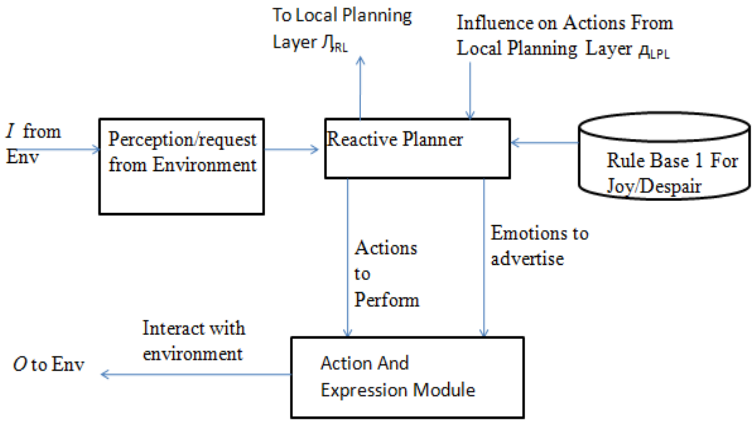


Figure 2: The reactive layer of EIPSA

3.2. Local Planning Layer

This layer is responsible for performing actions that lead to achievement of its individual goal and performing action in pursuit of success. It takes the perception of environment and abstraction from the reactive layer as Ԓ$_{RL}$ .Updates the beliefs, generates new desires and intentions. These in turn generate experience of emotions by the EAM (Emotion Arising Module) on basis of rule base 2. The emotions that are mapped on this layer are Adventure motivation and fear. The functionality of these is as follows

Adventure motivation is triggered if the agent has a high success ratio is greater than or equal to a quantitative threshold known as *Thresh motive* . It motivates the agent to perform risky tasks that are not previously defined in its action set like bonding with and agent for collaboration or performing an innovative action that does not have its utility defined to the agent. Innovation is also carried out this layer to find out new and more productive ways to perform the tasks and to achieve goal this is a result of adventure motivation. The rules "Trigger Adv Motive" contain the rules for triggering adventure motivation. The internal schematic of this layer is given in Figure 4 and the rule is as follows:

Start Rule" Trigger Adv Motive"

If Success (Ԓ$_{RL}$)>="Thresh motive"/* judge success ratio from abstraction of reactive layer */

Then

Risk=Trigger Adventure motivation (Success (Ԓ$_{RL}$))/* Quantify the Level of risk taken*/

Suggest (Ԓ$_{LPL}$)□ Deliberate (Risk) /* plan a new innovative action */

End Rule

The outcomes of the action may have productive outcomes or may result in total loss of resources and computation. To provide BIS (Behavior Inhibition System) for this emotional state ensuring that it does not do something that is too reckless that may result in too much loss by the rule "Fear Protect".

Start Rule "Fear Protect"

If Suggest (Ԓ$_{LPL}$)>="reckless"/* judge If suggested action does not damage the goals beyond recovery */

Then

Risk=Trigger Fear (Suggest (Ԓ$_{LPL}$)) /* Activate behavior inhibition through fear */

Risk□ **Decrement** (Risk) /* Decrease the amount of risk taken*/

End Rule

However if it achieves repeated success in risky actions the amount of risk involved is increased until a threshold of risk is achieved that point Fear kicks in and stops the agent from taking more risk. Another trigger for fear to be aroused is that risky action that was selected by the agent led to a failure or loss. The amount of fear experienced is based on self preservation of the goals and is inhibited by high success rate so the by the rule "Fear Quantifier" which is as follows:

Start Rule "Fear Quantifier"

If Success ($Л_{RL}$) ="updated"/* judge if the success ratio has changed from abstraction of reactive layer */

Then

Reckless=Quantify Fear (Success ($Л_{RL}$))/* Quantify the Threshold when the Fear is triggered*/

End Rule

After performing this action the abstractions are sent to the $Л_{LPL}$ are sent to the social planning layer this includes the emotions the emotional state of reactive and local planning layers and abstraction about environment related to social affairs of the agent.

3.3. Social Planning Layer

All The Social planning layer deals with social affairs of the agent that include bonding and interactions with other agents and its contribution to the MAS(Multi Agent System) .Making the agent more proactive and socially intelligent in relationship building .Also makes it aware of its own social status in society and about the status of agents its interacting with. This enables it to handle agents of different social value differently making it more intelligent and adaptive towards situation at hand.

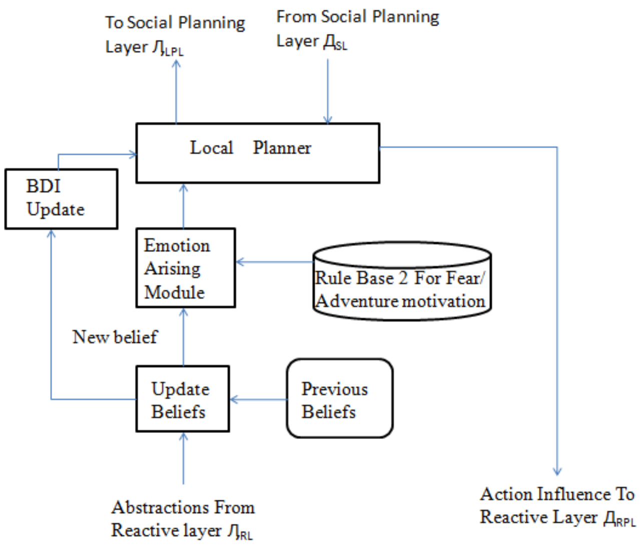


Figure 3: The Local Planning Layer of EIPSA

For example limiting the amount of Dislike shown towards an agent who is superior or to one holding required resources may put a setback in achieving its goals. This triggers the dislike emotion by Rule "Dislike".

Start Rule "Dislike"

If Interaction($Л_{LPL}$,Agent name) ="loss\Failure"/* judge if the interaction with the agent was a failure */ Fig.

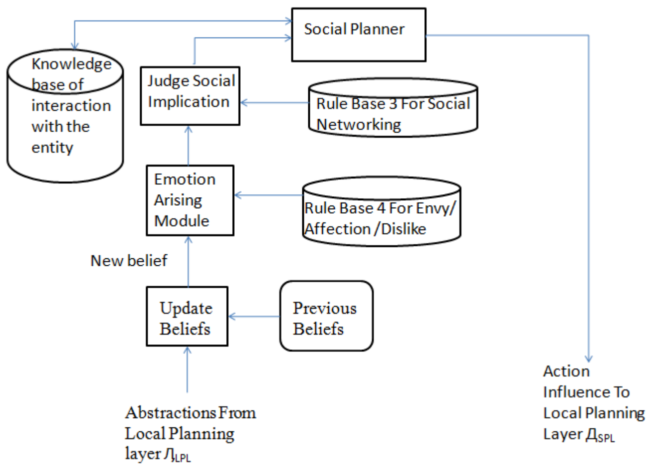


Figure4: The Social Planning Layer of EIPSA

Then

Relation Status = Previous Interaction Record (Agent name)/* load the previous interaction record */ (Relation Status, Agent name) □ Update (Relation Status, Agentname, Quantify (Failure (Л$_{LPL}$))/* Quantify the extent of losses and make decrement in unfriendly behavior with that agent */

End Rule

Liking or having affection to the ones that aided it in achieving sub goals or success. It is also triggered when an agent agrees to share its resources. This is controlled by rule base 3 by the Rule "Affection".

Start Rule "Affection"

If Interaction(Л$_{LPL}$,Agent name) ="Success"/* judge if the interaction with the agent was successful or not */

Then

Relation Status = Previous Interaction Record (Agent name)/* load the previous interaction record */ (Relation Status, Agent name) □ Update (Relation Status, Agentname, Quantify (Success (Л $_{LPL}$)) /* Quantify the extent of success and make increment in friendly behavior with that agent*/

End Rule

The emotions mapped on this layer are liking/affection, Disliking/hatred and envy. The functionality of these emotions is defined by rule base 4.

The agent manages a unique knowledgebase for all the agents it interacts with and the results of these are stored. The agents that have collaborated and completed their commitment get liking from the agent and others making false commitment and denying requests are disliked and further interactions are avoided with them .But Agents with whom affecting has been established are prone to get more favors from the agent this is managed trough rule "ShareResource". Also the social implication of granting or denying the request is considered as local planning layer may suggest not sharing resource as a rational action but the social implication of that is that other agents would also deny future requests for resources.

Start Rule “Share Resource”
If Request ($Ԯ_{LPL}$,Agent name, Realtion Status, Reactive-Joy, Success ($Ԯ_{LPL}$)) < ”reckless” **AND** Social Implication =” productive” /*Evaluate whether to grant request or not */
Then
Directive($Д_{SPL}$)□Grant Request (Agent name, request)/*Grant request */
Else
Directive($Д_{SPL}$)□Deny Request(Agent name ,request)/*Deny request */

End Rule

But resource sharing is also governed by other factors like success rate and other emotional states along with social outcomes of accepting the request or denying it. It receives abstraction $Ԯ_{LPL}$ from the local planning layer.

Also it can enhance or inhibit the expression of emotion towards other agents; this helps it to be more autonomous as it may strive to achieve its goal remaining in limits of laws implemented in the society. Rule “Social BIS” is responsible for it.

Start Rule “Social BIS”
If (Interacted(Agent name, Realtion Status)=Superior **OR** Holds Resource)
Then
Directive($Д_{SPL}$)□Suppress (Dislike Expression)/*Grant request */
Else
Directive($Д_{SPL}$)□Boost(Dislike expression)/*Deny request */
End Rule

To ensure a proactive behavior agent periodically inquires the success rate of other agents in its surrounding according to Rule Base 4. If it sees itself lagging behind from the average success ratio advertised by its neighbors it will be motivated to work harder or show more proactive behavior. That is if it has the resources or actions to achieve its task. Also it will keep in calculations the success rate of itself to whether take a risk or not. To achieve this it triggers “Social Envy” rule.

Start Rule “Social Envy”
If Success (Neighbor agents) > Success (self)
Then
Proactive□ **Increment** (Proactive) /*Increase proactive behavior */
End Rule

Keeping all these factors in calculation a decision is made by the social planning layer and the directives $Д_{SPL}$ are passed down to the local planning layer as shown in Fig 4. It passes the directives $Д_{LPL}$ to the reactive layer. The reactive layer uses these as input to the action and expression module and an action from the action set is chosen executed giving output *O* to the environment.

4. Case Study

To test our approach, we designed a grid of agents in a virtual world EIS (Emotionally Intelligent Society). This virtual society was scattered with 18 clones of EIPSA (that represents particular process industry), having a unique multipliers for the emotions. In this virtual world the agents (or process industry entity) are assigned to build a product that requires different components or services for completion. Each of the agents owns one or more of the resource type to complete the product. These resources are randomly distributed between the agents. Thus EIPSA grid must interact with each other within EIS to complete their task. Agents holding more resources are assumed to be more influential than others having fewer resources. With innovative actions were assigned random success values.

The agents interacted with each other to collaborate to find common ground and prosper collectively as a team. Suring the same time they were competitive within their team, but also on global prospective. This is done under influence of social planning layer. The agents select action request acceptance and refusal depends on the social status of agent they are dealing with. In other words the number of resources held by an entity defines the probability for collaboration. This is coupled with records of previous interactions with the partner under consideration. The job of innovation within the entity is delegated to local planning layer. This layer also takes care of the personal benefits and profit of the entity and ensures that personal goals are also met.

The advertisement of emotional states, interaction with other agents and environment is done by the reactive layer for the process entity. The actions are performed by this layer based on directives sent to it by upper layers. Another set of agents were assigned the same tasks but were not mapped with emotions. The resource allocation and environment variable were kept the same and then the performances of both sets of agents were measured. EIPSA without emotions performs a staggering 43% difference in time to complete the tasks, also producing more productive results through experimentation and innovation. For this test ten agents of each type were activated in the similar environments and results were based on the average completion times of tasks.

5. Conclusion and Future Work

All EIPSA agents are socially aware of their position in the MAS society that enables them to operate with a global prospective and understanding of society enabling it to plan for long term achievement of goals. Social awareness makes them aware of their place within the society and with respect to other agents they are dealing with.

Awareness helps them to suppress or boost appropriate behaviours that suit the social value and the social rules. Agents have the ability to interact and transmit emotions to others, enabling them to bond with each other, and helping them in further collaborations even providing each other with favours that would be risky for them. Innovation is the most striking feature of EIPSAs, i.e., having specified success rate agents are able to innovate and to try to discover new ways to accomplish common goals. The innovation provides the possibility of finding more efficient ways to solve problems. Resource sharing and negotiations are completely autonomous needing no outside intervention.

Innovation and collaboration are two features that are required by any entity in process industry to flourish and stay competitive in market. EIPSA is a novel approach to achieve. As it is one package that automates the process of collaboration, it actively protects the best interests of the entity owning it. EIPSA agent's test results prove our claim: emotions can also be used to enhance agent performance, just like utility to in HCI to improve user friendliness. In future, other emotions can be used according to the application, customization on how these emotions are implemented.

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