An Approach to Emotion-based Abstract Argumentative Reasoning

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Abstract. Most of work on reasoning and decision-making in virtual agents relates the choices with a exhaustive exploration, analyzing every possible alternative and implication, and trying to maximize some utility measure in order to make the best decision. Humans, however, seems no reason and make decisions naturally in this way. As authors such as Herbert A. Simon [10] have proposed, humans seems to develop a concept of bounded rationality, according to which human reasoning process and decision-making is bounded to a part of reality at a time as a focussing effect. According some psychologists, focus of thought is one of the main purposes of emotions in humans.
Using an abstract framework, in this work we propose an approach to consider emotions as an argument-selection heuristic towards the ability for an agent to reason and act in a believable manner. Influenced by emotions, the agent will produce a line of reasoning according to the evolution of its own emotional state.

1 Introduction

The study of emotions in Artificial Intelligence is a novel area of research with recently increased interest. Although emotions are often seen as being an obstacle to rational reasoning, when constructing agents that interact with humans the modeling of emotions play a relevant role. In several scenarios, such as virtual simulations or interactive digital entertainment, a model of emotions may contribute to create *believable* agents. Even more, psychological and neurological evidence suggests that emotions are relevant and necessary for rational behavior [12], specially in social contexts [5].

We are interested in how emotions affect the behavior of an agent, specially in the process of reasoning for decision making. In particular, in this paper the focus is put on the study of argumentation processes influenced by emotions. Argumentation is an important subject of research in Artificial Intelligence and it is also of interest for logicians, philosophers, communication theorists, and other researchers in several disciplines. A form of argumentation is present in many activities, most of them related to social interactions between humans, as

in civil debates, legal reasoning or every day dialogues. In essence, the subject of study in this discipline is the use of *arguments* as a form of reasoning. An argument is a piece of reasoning that supports a claim from certain evidence. The central idea in Argumentation is that a proposition or claim will be accepted if there exists an argument that supports it, and this argument is regarded as acceptable with respect to an analysis performed considering all the available counterarguments. Therefore some of the arguments will be *acceptable* or *justified* or *warranted* arguments, while others will be not. Usually, a rational agent will examine its knowledge base in order to find arguments for and against the original claim, and for an against arguments found in the same process. This search is exhaustive, and the agent constructs a *dialectical tree* where arguments and counterarguments are analyzed. In this tree, some arguments include information which is closely related to the original topic while others are challenging or defending information of minor topics in the overall discussion. When modeling a rational agent with intended believable behaviour, this exhaustive analysis is counterproductive.

In this work we propose an approach to consider emotions as an argument-selection heuristic towards the ability for an agent to reason and act in a believable manner. Influenced by emotions, the agent will produce a line of reasoning according to the evolution of its own emotional state. This is a natural behavior. Suppose a fearful person is in his house, and suddenly it realizes there is an increasing smoke from the kitchen. Although there may be several explanations for this, such as overcooked cake or curtains on fire, a fearful person may conclude the kitchen is on fire. There may be reasons to run away or to fight this fire with an extinguisher. However, a fearful person that experiments a strong increase of fear will find reasons to run away, no matter how sound other actions are. Arguments for running are highly selectable, cause they are consistent with the emotion of fear.

We are not proposing a new theory of emotions, but a form of integration of emotion models with argumentation. In our framework, an emotional agent is equipped with an argumentation framework and an internal emotional context. Both elements are treated in an abstract level, without specifying how arguments are constructed nor what is the implemented emotional model. The emotional context may change as arguments are identified by the agent. Also, the relevance of arguments is influenced by the emotional context of the agent. If an agent experiences extreme fear, it may start *thinking* about arguments that deepens the fear emotion, which in turn leads to a blocking of more anti-fear arguments.

This paper is organized as follows: In section 2, we show a brief review on the work done over integration of emotions on virtual agents. In section 3, we make a short revision on abstract argumentation frameworks. In section 4, we present the formalism: the proposed argumentation framework, the agent main components and the functions that help the agent to select emotionally relevant arguments. Finally, we draw conclusions and mention some future work.

2 Emotions in Agents

The concept of emotion is somehow discussed, with little consensus on its formal meaning. There are, however, various approaches to emotion characterizations proposed by the affective computing comunity, such as the OCC model [8], which decomposes emotions according as reactions to the consequences of events, consequences of an agent's actions, and an agent's attitude towards certain objects. This approach, as well as these presented in [9] and [4] among others, are knewed as appraisal theories of emotion. According to the appraisal theories, the human emotions arise as result of cognitive evaluations over elements on the environment. The appraisal of such elements is made concerning some set of fixed variables (such as event desirability, relevance, controllability) that differ between particular theories. The OCC model is used in some agent architectures [11, 1] since it introduces a computationally tractable model of emotions. A formalization of the action tendency using OCC model was presented in [12], introducing a mechanism for limiting and ordering options in an agent's action selection process. The EMA model [4, 7] is a particularly interesting approach since, in addition to the arousal of emotions through the event appraisal, it presents different coping strategies [6] in order to model how the elicited emotions influence over other cognitive functions, such as attention, believes, intentions, actions and many others, influencing also over future appraisals. Similarly, in FAtiMA architecture [1] an OCC-based appraisal mechanism is combined with a continuous planner that implements problem-focused and emotion-focused coping.

Our proposal can be associated with the appraisal theories, since in our work the relation between cognitive elements (represented through arguments) and the elicited emotions is made explicitly. Also, as in EMA model [7], in our framework the elicited emotions have effect on other cognitive functions. However, unlike in EMA and the other appraisal models, in which the focus of the appraisal is set in the elements of the environment (appraising strictly each one of these according to a fixed set of variables), in our framework the arising of emotions is directed by what the agent thinks (which may include some current elements of the environment). We can also relate our framework with [12] in the sense of being a criteria for emotion-based selection. However, we are focused in the agent's inner process of reasoning through argumentation, instead of actions formalized by an agent specification language.

3 Argumentation frameworks

One of the main concerns in Argumentation Theory is the search for rationally based positions of acceptance in a given scenario of arguments and their relationships. This task requires some level of abstraction in order to study pure semantic notions. Abstract argumentation systems [2, 13] are formalisms for argumentation where some components remain unspecified, being the structure of an argument the main abstraction. In this kind of system, the emphasis is put on the semantic notion of finding the set of accepted arguments. Most of these

systems are based on the concept of *attack* represented as an abstract relation, and extensions are defined as sets of possibly accepted arguments. For two arguments $\mathcal{A}$ and $\mathcal{B}$, if $(\mathcal{A}, \mathcal{B})$ is in the attack relation, then the acceptance of $\mathcal{B}$ is conditioned by the acceptance of $\mathcal{A}$, but not the other way around. It is said that argument $\mathcal{A}$ *attacks* $\mathcal{B}$, and it implies a priority between conflicting arguments.

The simplest abstract framework is defined by Dung in [2]. It only includes a set of abstract arguments and a binary relation of attack between arguments. Several semantics notions are defined and the Dung's argument extensions became the foundation of further research. Dung defines several argument extensions that are used as a reference for many authors. The formal definition of the classic argumentation framework follows.

Definition 1. [2] *An argumentation framework is a pair* $AF = \langle AR, attacks \rangle$ *where* AR *is a set of arguments, and* $attacks \subseteq AR \times AR$.

A set of accepted arguments is characterized in [2] using the concept of *acceptability*, which is a central notion in argumentation, formalized by Dung in the following definition.

Definition 2. [2] *An argument* $\mathcal{A} \in AR$ *is acceptable with respect to a set of arguments* S *if and only if every argument* $\mathcal{B}$ *attacking* $\mathcal{A}$ *is attacked by an argument in* S.

If an argument $\mathcal{A}$ is acceptable with respect to a set of arguments S then it is also said that S *defends* $\mathcal{A}$. Also, the attackers of the attackers of $\mathcal{A}$ are called *defenders* of $\mathcal{A}$. Acceptability is the main property of Dung's semantic notions, which are summarized in the following definition.

Definition 3. *A set of arguments* S *is said to be*
– *conflict-free if there are no arguments* $\mathcal{A}, \mathcal{B}$ *in* S *such that* $\mathcal{A}$ *attacks* $\mathcal{B}$.
– *admissible if it is conflict-free and defends all its elements.*
– *a preferred extension if* S *is a maximal admissible set.*
– *a complete extension if* S *is admissible and it includes every acceptable argument w.r.t.* S.
– *a grounded extension if and only if it is the least complete extension.*
– *a stable extension if* S *is conflict-free and it attacks each argument not in* S.

4 Emotions and Arguments

In this section, we present the components that integrates an agent that reasons by sucesivelly selecting arguments following an emotional criteria.

4.1 Emotional Context

One of the main elements on the formalism is a dynamic component, formed by a collection of all emotions that the agent currently experiences and its current

values. This collection is called the agent's *emotional context*. As stated before, we treat emotions in an abstract level and no references to a particular emotion model is made. A single emotion is represented as a positive literal and it is called here an *emotional factor*.

Definition 4. *(Emotional Factor) An Emotional Factor EF is a positive literal in the form $ef\_name(p_1, \ldots, p_n)$, where the functor ef_name is the emotional factor name, and $p_1, \ldots, p_n$ are terms.*

Examples of Emotional Factor can be *fear(fire)*, or *friendliness(kelly)*, the first representing the fear emotion toward the fire, and the second the attitude friendliness toward Kelly. Note that it is possible to implement the OCC emotion model by representing each one of the 22 emotions by an emotional factor, but, as remarked before, it is not the intention of this paper.

An emotion is not a binary condition (to have fear or not). It can appear with different intensities at different times. A valued emotional factor is an emotional factor with a numerical graduation representing intensiveness.

Definition 5. *(Valued Emotional Factor) A Valued Emotional Factor is a tuple $VEF = (EF, val)$ where IF is a Emotional Factor and $val \in \mathbb{Z}$ is a value asigned to the Emotional Factor.*

For example, a Valued Emotional Factor can be $(fear(fire), 5)$, representing that the emotion $fear$ toward the fire has an intensity of 5. The higher the value, the most intense is the emotion.

The emotional context of an agent is a collection of valued emotional factors, describing all the current emotions experienced by the agent and its intensities.

Definition 6. *(Emotional Context) An Emotional Context EC is a finite set of Valued Emotional Factors. Given a Emotional Context EC, for each pair of Valued Emotional Factors $VEF_i = (EF_i, v_i), VEF_j = (EF_j, v_j) \in EC$ where $VEF_i \neq VEF_j$, is $EF_i \neq EF_j$.*

For instance, the set $EC = \{(fear(fire), 5), (friendliness(kelly), 3), (sad(alone), 7)\}$ is an emotional context.

4.2 Emotional Argumentation Framework

The second main element is an emotionally extended framework in which the arguments are related with emotions by means of functions establishing both the emotional conditions for availability of the arguments and emotional effects triggered by arguments.

Definition 7. *(Emotional Argumentation Framework) An Emotional Argumentation Framework is a tuple $EAF = (Args, Attacks, EFs, AS, ES, ESE)$ where*

- *$Args$ is a finite set of Arguments,*
- *$Attacks \subseteq Args \times Args$,*

- EFs *is a finite set of Emotional Factors,*
- AS *is an Activation Stimuli Function* $AS : Args \to \mathbb{Z}$.
- ES *is an Emotional Stimuli Function* $ES : Args \times EFs \to \mathbb{Z}$,
- ESE *is a Emotional Side Effect Function* $ESE : Args \times EFs \to \mathbb{Z}$,

The arguments in $Args$ are not always available to be used. The main idea is that an argument has to satisfy a requeriment, i.e. it has to reach some *stimuli*, to become interesting to be used. Then the argument is said to be active. The amount of stimuli required for the activation of a particular argument A is determined by the Activation Stimuli Function. For an EAF $\Phi = (Args, Attacks, EFs, AS, ES, ESE)$, the Activation Stimuli Function AS for an argument $A \in Args$ is such that $AS(A)$ is the minimum amount of stimuli required by A in order to be activated.

We already have a way to know how much stimuli is required by a particular argument to be activated. But we say nothing about the way in which an argument obtain that required stimuli to be activated. In order to that, various elements are involved: These are the *emotional stimuli function*, the *contextual value function* and the *stimuli score function*.

The *Emotional Stimuli Function* indicates the effect (influence) that each internal factor has over the stimuli of each particular argument. In other words, for an argument A and for an emotional factor EF_i, the function returns the amount in which the current value of EF_i (in the EC) increases/decreases the stimuli of the argument. For an EAF $\Phi = (Args, Attacks, EFs, AS, ES, ESE)$, for each Emotional Factor $EF \in EFs$ and each argument $A \in Args$, the Emotional Stimuli Function ES is such that $ES(A, EF) = i$, where the value i represents that EF increases/decreases the stimuli of A i times the current value of EF. Suppose an argument A and the emotional factor $fear$. If $ES(A, fear) = i$, then the consideration of A is stimuled by the $fear$ emotion in the amount of i times the current value of $fear$ (obtained from the corresponding valued emotional factor in the current emotional context). For example, if $ES(A, fear) = 3$ and $(fear, 2)$ is a valued emotional factor in the emotional context, then the argument A is stimuled by $fear$ in $(2 * 3) = 6$ points.

As we can see from the previous function, is necessary to recover the current value of the emotional factor in order to calculate the real amount of stimuli provided by an emotional factor to the argument. To this end, we define the *Contextual Value Function* that returns the current value of a given emotional factor if it is present in the emotional context, 0 otherwise.

Definition 8. *(Contextual Value Function) Let* EF *be an Emotional Factor and* $EC = (VEF_1, VEF_2, \ldots, VEF_n)$ *an Emotional Context, where* $VEF_i = (EF_i, val_i)$. *The Contextual Value Function* $CV : EFs, EC \to \mathbb{Z}$ *is such that* $CV(EF, EC) = val_i$, *if* $\exists VEF_i \in EC$ *such that* $EF_i = EF$, *otherwise* $CV(EF, EC) = 0$.

Finally, the *Stimuli Score Function* cumputes the overall stimuli of the argument (how relevant this argument is in the given context), by considering the stimuli provided by all the emotional factors affecting the argument.

Definition 9. *(Stimuli Score Function) Let* $\Phi = (Args, Attacks, EFs, AS, ES, ESE)$ *be an* EAF*, where* $EFs = \{EF_1, EF_2, \ldots, EF_n\}$*, let* $A \in Args$ *be an argument and let* EC *be an Emotional Context. The Stimuli Score Function* $SSc_\Phi : Args \times EC \to \mathbb{Z}$ *is such that* $SSc_\Phi(A, EC) = \sum_{i=1}^{n} CV(EF_i, EC) * ES(A, EF_i)$.

Suppose the emotional factors $\{fear, sadness, anger, happiness, ...\} \in EFs$, the emotional context EC = ((fear,3), (sadness,2), (anger,4), (happiness,1), ...), an argument $A \in Args$, and suppose that $ES(A, fear) = 2$, $ES(A, sadness) = 2$, $ES(A, anger) = 1$, $ES(A, happiness) = 0$, and for all other emotional factor EF_k is $ES(A, EF_k) = 0$ (i.e. these do not influence A's stimuli). Then, $SSc(A, EC) = 3 * 2 + 2 * 2 + 4 * 1 + 1 * 0 + EF_k * 0 + \ldots + EF_n * 0 = 14$. This means that, in the *emotional context* EC, the argument A has a stimuli of 14 points. Note that the stimuli of the argument would be different in another emotional context. But, what does that particular value implies? Without a context, it is just a number. To become more meaningful it should be analyzed in relation to the stimuli of another arguments. For example, in a context in which such stimuli (14) is one of the highest argument's stimuli, it means that A is an interesting argument to be considered against other less stimuled arguments.

As we stated before, as well as the emotions influence the availability of arguments, the consideration of arguments have influence over emotions. That influence provides in our framework the dynamic nature that the emotional context has. The *Emotional Side Effect Function* indicates which is the emotional effect of each argument over each emotional factor, and thus, how each argument impacts over the current emotional context. For an EAF $\Phi = (Args, Attacks, EFs, AS, ES, ESE)$, the Emotional Side Effect Function ESE of an argument $A \in Args$ over an Emotional Factor $EF \in EFs$ is such that $ESE(A, EF) = \Delta i$, meaning that the dialectical use of A increments/decreases on Δi the value of EF on EC. The Emotional Side Effect Function determines the variation over the current value of EF in the EC caused by the use of an argument A. Δi represents the amount in which the Emotional Factor EF is increased or decreased. For example, consider an EC containing a VEF $(fear, 3)$, an argument A, and suppose that $ESE(A, fear) = -2$. If argument A is used in the dialectical process, then the value of $fear$ in the EC will be decreased by 2, so the actualized EC will contain the VEF $(fear, 1)$ instead $(fear, 3)$.

4.3 Emotionally Influenced Agent

An Emotionally Influenced Agent is defined by the two previous elements: an *emotional argumentation framework* and an *emotional context*. The emotional argumentation framework, as we present in the previous section, represents the set of available arguments, their attacks, the conditions for the arguments activation defined over the emotional context, and the variations caused by the arguments to the emotional context. The emotional context represents the set of all current emotional factors, and current values, that the agent experiences.

Definition 10. *(Emotionally Influenced Agent) An Emotionally Influenced Agent is a tuple* $Ag = (\Phi, EC)$*, where* Φ *is an Emotional Argumentation Framework and* EC *is the agent's Emotional Context.*

An agent reasons by progressive consideration of arguments, under an evolutive emotional context. In order to discover which arguments are currently active, the agent uses the *arousal function*, that returns the subset of activated arguments from the entire set. An argument is activated for an emotional context EC if its stimuli score according to EC reaches its activation stimuli.

Definition 11. *(Arousal Function)*
Let $\Phi = (Args, Attacks, EFs, AS, ES, ESE)$ *be an* EAS*. Let* EC *be an Emotional Context. The Arousal Function* $AF_\Phi : EC \rightarrow Args$ *is such that* $AF_\Phi(EC) = \{A \in Args \text{ such that } SSc_\Phi(A, EC) \geq AS(A)\}$

When an argument is considered, its associated *emotional side effects* are triggered, producing changes over the current emotional context, according to the Emotional Context Update Function.

Definition 12. *(Emotional Context Update Function) Let* $Ag = (\Phi, EC)$ *be an Emotionally Influenced Agent, where* $\Phi = (Args, Attacks, EFs, AS, ES, ESE)$*,* $EC = (VEF_1, \ldots, VEF_m)$ *is an Emotional Context with* $VEF_i = (EF_i, val_i)$*, and let* $A \in Args$ *be an argument. The Emotional Context Update Function* $ECV : ECs, Args \rightarrow ECs$ *is such that* $ECV(A, EC) = EC'$*, with* $EC' = (VEF'_1, \ldots, VEF'_m)$ *and* $VEF'_i = (EF_i, val'_i)$*, where for each* $VEF'_i \in EC'$ *is* $val'_i = val_i + ESE(A, EF_i)$*.*

Each time a new argument is considered, the emotional context variates as consequence. The sequence of arguments leading to an emotional context is called an *emotional argumentation stage*. It is represented by such a sequence and the concluding emotional context. This is formalized in the following definitions.

Definition 13. *(Argumentation Sequence) An Argumentation Sequence* $ASeq$ *is a sequence* $[A_0, \ldots, A_n]$ *such that* $\forall i A_i \in Args$*.*

Definition 14. *(Emotional Argumentation Stage) An Emotional Argumentation Stage* ST *is a pair* $(ASeq, EC)$ *where* $ASeq$ *is an Argumentation Sequence and* EC *is an Emotional Context. For an Argumentation Stage* ST_i*, we call* ST_i^s *to its Argumentation Sequence and* ST_i^e *to its Emotional Context.*

An agent starts from an initial Emotional Context EC_0 and an empty Argumentation Sequence [], which configures the initial emotional argumentation stage ST_0, and it reasons through successive transitions between emotional argumentation stages. It is possible to move from a stage ST_A to another ST_B through a Stage Transition, according to which an argument $X \in Args$ is selected and attached to the end of ST_A^s into the new Argumentation Sequence ST_B^s and the Emotion Context ST_B^e is obtained by applying the emotional side effects of the argument X over ST_A^e. Remember that not every argument in $Args$

is plausible to be considered for a transition from ST_A to another stage. Only activated arguments (the relevant ones in the actual context) are considered, i.e. the arguments in $AS(ST_A^e)$.

Definition 15. *(Stage Transition) Given the Emotional Argumentation Stages ST_A, ST_B and the argument $X \in AS(ST_A^e)$, the Stage Transition $ST_A \xrightarrow{X} ST_B$ is such that $ST_B = ([ST_A, X], ECV(ST_A^e, X))$.*

4.4 Focused Selection

We have established so far the condition that an argument, in order to be considered in an emotional argumentation stage, must be activated according to the previous stage's emotional context. However, since the emotional context variates dynamically as a result of the considered arguments, and thus that variation changes the conditions under which an argument is selected to be considered into the next stage, the order in which the arguments are introduced are very relevant to the final set of considerated arguments. We propose then, as an extra condition, that for an argument to be selected in an emotional argumentation stage, in addition to be activated in that stage, it must be contextually preferred over all other available (actived) but not yet used argument according the stage's emotional context. An argument A is contextually preferred to another argument B according to an emotional context EC if the stimuli for A is at least as much as the stimuli for B.

Definition 16. *(Contextual Preference) Given an Emotional Context EC_i and two arguments $A, B \in AF(EC_i)$, we say A is preferred over EC_i with respect to B if and only if $SSc(A, EC_i) \geq SSc(B, EC_i)$.*

Proposition 1. *Given the Arguments $A, B \in AF(EC_i)$, if $SSc(A, EC_i) = SSc(B, EC_i)$ then both A is preferred over EC_i to B and B is preferred over EC_i to A.*

The contextually preferred set for a emotional argumentation stage is the set of all arguments that are not present in the argumentation sequence of that stage and are contextually preferred to every other argument that is not in the argumentation sequence of the stage.

Definition 17. *(Contextually Preferred Set) Given an Emotional Argumentation Stage ST_i and the EAF $\Phi = (Args, Attacks, AS, ES, ESE)$, the Contextually Preferred Set $CPS_\Phi : ST \rightarrow Args$ is such that $CPS_\Phi(ST_i^e) = \{A \in Args - ST_i^s$ if A is preferred over ST_i^e to every Argument$B \in Args - ST_i^s\}$.*

Since we want the emotional relevance to be preserved through the reasoning process, we state that every Stage Transition must be a Focused Stage Transition.

Definition 18. *(Focused Stage Transition) Given an EAF Φ, a Stage Transition $ST_A \xrightarrow{X} ST_B$ is a Focused Stage Transition if and only if $X \in CPS_\Phi(ST_A)$.*

Suppose the agent is in the stage $ST_2 = ([A_0, A_1], EC)$, and has the arguments $\{A_0, A_1, A_2, A_3, A_4, A_5\}$ with $AS(A_0) = 3$, $AS(A_1) = 2$, $AS(A_2) = 5$, $AS(A_3) = 7$, $AS(A_4) = 4$, $AS(A_5) = 9$, $SSc(A_0, EC) = 11$, $SSc(A_1, EC) = 10$, $SSc(A_2, EC) = 5$, $SSc(A_3, EC) = 8$, $SSc(A_4, EC) = 8$, and $SSc(A_5, EC) = 5$. Although arguments A_0 and A_1 are actived, transitions $([A_0, A_1], EC) \stackrel{A_0}{\rightarrow} ([A_0, A_1, A_0], EC')$ and $([A_0, A_1], EC) \stackrel{A_1}{\rightarrow} ([A_0, A_1, A_1], EC')$ are not possible since A_0 and A_1 are already on the base sequence. A_5 is not actived, since $AS(A_5) > SSc(A_5, ST_2)$. Both A_2, A_3 and A_4 are actived, but only transitions $([A_0, A_1], EC) \stackrel{A_3}{\rightarrow} ([A_0, A_1, A_3], EC')$ and $([A_0, A_1], EC) \stackrel{A_4}{\rightarrow} ([A_0, A_1, A_4], EC')$ are Focused Stage Transitions since $A_3, A_4 \in CPS_{\Phi}(EC)$ because $SSc(A_3) = SSc(A_4) > SSc(A_2)$.

To put it in a more meaningful example, suppose an agent got the argument A concluding that the kitchen is on fire and the argument B concluding to run away. Suppose there are another arguments concluding alternatives to run away, such as to extinguish the fire, to call to the fire department, to put aside some important things, and so on. In order to be a *focused stage transition*, the stage transition $([A], EC) \stackrel{B}{\rightarrow} ([A, B], EC')$ must be such that B (the argument for run away) is a *contextually preferred argument* over EC (the emotional context that results from the evaluation of the argument A concluding that the kitchen is on fire). That is to say that the argument for run away must be, over such emotional context, at least as good (emotionally stimuled) as the alternative arguments.

In Figure 1, we show a general schema about a transition from an emotional argumentation stage to another, making visible the relations between the main previous concepts. In that schema we can see that:

1. From the stage ST_4 and by the help of AS and SSc functions, the sets of active ($AF(Args, EC_4)$) and contextually preferred ($CPS(ST_4)$) arguments are obtained.
2. An argument (A_4) is selected from the set of *contextually preferred* ones. There are not restrictions on which of these must be selected.
3. Argument A_4 is added to the argumentation sequence in the stage ST_5.
4. The emotional side effects of A_4 (defined by the ESE function) are triggered. Thus, the new emotional context EC_5 is generated from the application of the emotional side effects over the previous emotional context EC_4.

Summarizing, in items 1 and 2 it is shown how the argument that will lead to the transition is selected. In items 3 and 4 it is shown the effect of the transition in the reasoning process. The new emotional argumentation stage ST_5 will configure the starting point for the next stage transition.

As a final analysis, consider jointly the interactions between the components: From a set of available arguments, the emotional side effects may differ from an argument to another. Thus, depending on which stage transition is selected by an agent from a stage (i.e. which is the selected argument), it may result on different emotional contexts for the next stage. Since the activated and the contextually preferred sets of arguments depends directly on the emotional context, the selected argument for a transition depends on the activation and contextual

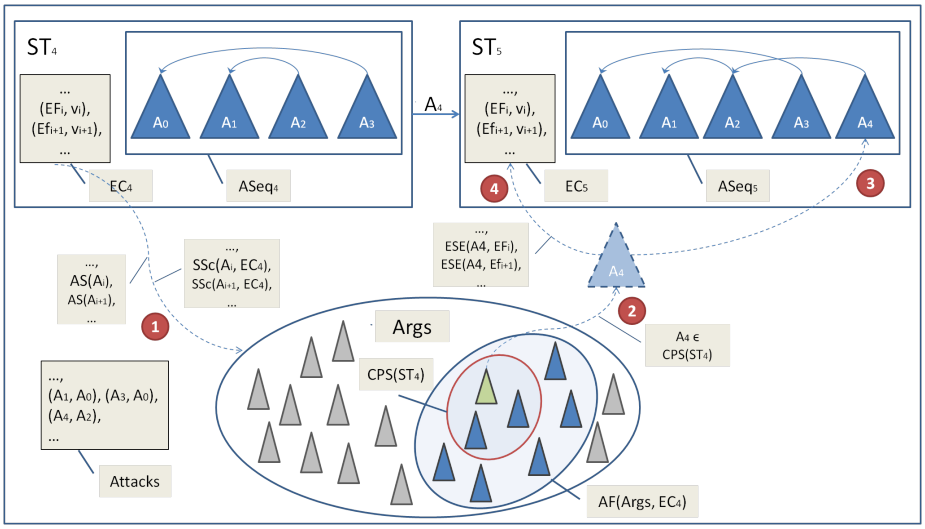

Fig. 1: Transition between emotional argumentation stages

preference, and the emotional context depends on the selected argument again, then the argument selection in a stage transition influences indirectly on the argument selection on following stages transitions. In such way, configuring correctly both the emotions triggered by the consideration of the arguments and the emotional conditions for the arousal of these (i.e, the AS, ES and ESE functions in the framework), we think it is possible for an emotionally influenced agent to follow a coherent reasoning sequence based on emotions.

4.5 Extensions over an emotional argumentation stage

Given a emotional argumentation stage ST_n, note that the set of arguments in ST_n^S is a subset of $Args$ and the attacks beween arguments in ST_n^S are a subset of $Attacks$. As may exist contradictions between the arguments on ST_n^S (and then there may be contradictory conclusions), it may be required to decide what to believe in the stage. In order to obtain a consistent set of arguments, it can be used any Dung's extension [2] over the set of arguments on ST_n^S. However, we mantain useful emotional information at each stage. We believe then that we can develop a more suitable method that takes advantage of the emotional information in order for the agent to can decide what to believe.

5 Conclusions and future work

In this work we have presented a framework for emotionally influenced reasoning through the use of arguments enriched with emotional conditions and emotional effects. We have introduced the functions through which emotions and arguments are related. Next, we have defined an emotionally influenced agent, that is an agent with an emotional context and an emotional argumentation framework, in

such way it reasons by selecting arguments with the higher emotional stimuli, and being emotionally influenced by the use of the arguments. We state the necessary conditions under which an argument can be selected for passing from an argumentation stage (an step on the reasoning process) to another. We think it is an interesting approach to make the reasoning process of an agent more focused, each time avoiding arguments that are not emotionally-relevant for the agent, simplifying the amount of information that an agent uses in reasoning.

For future work, we propose to define an emotion-based semantic that determines what to believe from the set of conclusions supported by the arguments considered in a given emotional argumentation stage.

We also propose to integrate this formalism with the DeLP argumentation system [3]. In such integration, the emotions could be related to logical rules instead of arguments (i.e., a rule should reach some emotional interest to be used, and it would trigger some emotional changes as a result of its use). Thus, an activated argument could be formed by the chaining of activated rules, and a contextually preferred argument could be formed by the chaining of most emotionally-relevant rules.

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