Intelligent NPCs for Educational Role Play Game

Mei Yii Lim[1], João Dias[2], Ruth Aylett[1], and Ana Paiva[2]

[1] School of Mathematical and Computer Sciences,
Heriot Watt University,
Edinburgh, EH14 4AS, Scotland
{myl, ruth}@macs.hw.ac.uk
[2] INESC-ID, IST, Taguspark,
Av. Prof. Dr. Cavaco Silva,
2744-016 Porto Salvo, Portugal
{joao.dias, ana.paiva}@gaips.inesc-id.pt

Abstract. Video games in general and educational role play games in particular would increase in believability if Non Player Characters reacted appropriately to the player's actions. Realistic and responsive feedback from game characters is important to increase engagement and enjoyment in players. In this paper, we discuss the modelling of autonomous characters based on a biologically-inspired theory of human action regulation taking into account perception, motivation, emotions, memory, learning and planning. These agents populate an educational Role Playing Game, ORIENT (Overcoming Refugee Integration with Empathic Novel Technology) dealing with the cultural-awareness problem for children aged 13 to 14.

1 Introduction

Non Player Characters (NPCs) vary in importance and may play roles of bystanders, allies or competitors to the player in the fictional world of computer games. These NPCs' behaviour is usually scripted and automatic, triggered by certain actions of or dialogue with the player. This method is cumbersome and produces gameplay that is repetitive and thus unnatural. In more advanced Computer Role Playing Games (CRPGs), NPC behaviour can be more complex and players' choices may affect the course of the game, as well as the conversation (eg. Fallout3[3]). However, true dialogues with NPCs are still a problem. In most CRPGs, the same dialogue option chosen by the player will usually receive the same reply from the NPC.

It is beneficial for NPCs to be believable and 'real' so that the player will enjoy interacting with them. Characters that are able to express their feelings and can react emotionally to events are more life-like. NPCs capable of dynamically reacting to player actions in reasonable and realistic ways are therefore very

[3] http://fallout.bethsoft.com/eng/home/home.php

desirable. Natural interaction between NPCs and the player is very important because it transforms the challenge of the game from a technical one to an interpersonal one, and thus may increase both the enjoyment and the engagement of players. However, up-to-date, real autonomous agents that are capable of improvisational actions, appear to be able to 'think', and have desires, motivations and goals of their own, are still rare in games.

2 Educational Role Playing Game

Researchers pointed out that play is a primary socialization and learning mechanism common to all human cultures and many animal species. 'Lions do not learn to hunt through direct instruction but through modeling and play.' [1]. Games are effective because learning takes place within a meaningful context where what must be learned is directly related to the environment in which learning and demonstration take place.

How can cultural studies be made exciting? Perhaps through an educational role play game. For instance, one in which the student is a space command member who must master the patterns of behaviour of an alien culture and pass as their friend within a digitally simulated world. The students will have interesting missions to keep them motivated and engaged. This approach shifts the students' cognitive effort from reading about educational content to hands-on experience of achieving compelling goals. Members of a team can cooperate with each other to solve the team's conflicts with other agents, whether a player from another team or an NPC. Such an opponent must be perceivable as endowed with a personality if the player is to be able to suspend disbelief in the way engagement with the storyworld requires.

In ORIENT[4], our game world is designed in just such a way. It is an interactive computer assisted role-playing game where three players act as visitors to a foreign planet that is inhabited by an alien culture. In order to save the planet from an imminent catastrophe, the players have to cooperate with the alien inhabitants, which can only be achieved by integrating themselves into the culture. Since the game incorporates a social setting, each NPC must be able to establish social relationships with other NPCs and the players to ensure successful collaboration. ORIENT characters must be able to recognise cultural differences and use this information to adapt to other cultures dynamically. The ability to empathise, that is, to detect the internal states of others and to share their experience, is vital to the formation of long-term relationships. Since enhancement of integration in a cultural group relies both on the understanding of the internal states of the persons involved and their affective engagement, both cognitive [2] and affective [3] empathy are relevant. Additionally, previous experience is crucial in maintaining long-term social relationships, which means a requirement for an autobiographic memory [4] is inevitable. Through an ability to retrieve previous experiences from its autobiographic memory, an NPC

[4] http://www.e-circus.org/

will be able to know how to react sensibly to a similar future situation. Thus, ORIENT provides a good case study for modelling NPCs with adaptive and improvisational capabilities, that possess autobiographical memory, individual personality and show empathy.

3 Related Work

Much recent work has been carried out on developing agents with autonomous capabilities. Some of this work focuses on physiological aspects while some focuses instead on cognitive aspects of human action regulation. Examples of existing physiological architectures are those by Cañamero [5], Velásquez [6] and Blumberg [7]. Cañamero's architecture relies on both motivations and emotions to perform behaviour selection for an autonomous creature. Velásquez developed a comprehensive architecture of emotion based on Izard's four systems model [8], focusing on the neural mechanism underlying emotional processing. Blumberg developed an animated dog, Silas that has a simple mechanism of action-selection and learning combining the perspective of ethology and classical animation. A more recent implementation of the model is AlphaWolf [9], capturing a subset of the social behaviour of wild wolves. These architectures are useful for developing agents that have only existential needs but are too low level for characters which require planning and storytelling capabilities as in ORIENT. Another problem of these architectures is that the resulting agents do not show emotional responses to novel situations because all behaviours are hard-coded.

On the cognitive end, the OCC cognitive theory of emotions [10] is one of the most used emotion appraisal model in current emotion synthesis systems. The authors view emotions as valenced reactions that result from three types of subjective appraisals: the appraisal of the desirability of events with respect to the agent's goals, the appraisal of the praiseworthiness of the actions of the agent or another agent with respect to a set of standards for behaviour, and the appraisal of the appealingness of objects with respect to the attitudes of the agent. Numerous implementations of the theory aimed at producing agents with a broad set of capabilities, including goal-directed and reactive behaviour, emotional state and social knowledge exist, beginning with the Affective Reasoner architecture [11], the Em component [12] of the Hap architecture [13], EMA [14], FAtiMA (FearNot! Affective Mind Architecture) [15] and many more. On the other hand, most deliberative agent architectures are based on the BDI (Beliefs, Desires, Intentions) model [16]. The ways BDI agents take their decisions, and the reason why they discard some options to focus on others, however, are questions yet to be answered. These problems are associated with the BDI architecture itself and not with a particular instantiation. Furthermore, BDI agents do not learn from errors and experience.

In order to create purely autonomous agents, we argue that a hybrid architecture combining both physiological and cognitive aspects is required. Some examples of this type of architecture are those by Sloman [17], Jones [18], Oliveira [19] and Dörner [20]. The agent cognitive processes should result from lower-level physiological processing and the outcome of cognitive processes should influence the agent's bodily states, producing complex behaviours that can be termed emotional. Damasio [21] provides neurological support for the idea that there is no 'pure reason' in the healthy human brain but emotions are vital for healthy rational human thinking and behaviour which means both cognitive and physiological systems are essential parts of intelligent agents.

4 ORIENT Agent Mind

4.1 Inspiration

The ORIENT agent mind (i.e. the program that controls NPCs' behaviour) is built upon FAtiMA [15] architecture applied in FearNot!v2.0. FAtiMA was an extension of a BDI architecture, hence, faced the problem of ambiguity in its decision making processes common in any BDI architecture. It has a reactive and a deliberative appraisal layer. The reactive appraisal process matches events with a set of predefined emotional reaction rules while the deliberative appraisal layer generates emotions by looking at the state of current intentions, more concretely whether an intention was achieved or failed, or the likelihood of success or failure. After the appraisal phase, both reactive and deliberative components perform practical reasoning. The reactive layer uses simple and fast action rules that trigger action tendencies. On the other hand, the deliberative layer uses the strength of emotional appraisal that relies on importance of success and failure of goals for intention selection. A goal is activated only if its start conditions are satisfied. Each goal also contains success and failure conditions.

The main reason for choosing FAtiMA is that it incorporates the OCC theory [10], has a continous planner [22] that is capable of partial order planning and includes both problem-focused and emotion-focused coping [23] in plan execution. The OCC theory models empathy easily because it takes into consideration appraisals of events regarding the consequences for others. It is - as far as we know - the only model that provides a formal description of non-parallel affective empathic outcomes (i.e. emotions that take a bad relationship between one agent and another into account, e.g., gloating and resentment). Moreover, since the OCC model includes emotions that concern behavioural standards and social relationships based on like/dislike, praiseworthiness and desirability for others, it allows appraisal processes that take into consideration cultural and social aspects, important for ORIENT agents.

However, the number of empathic emotional outcomes described in OCC: happy-for, resentment, gloating and pity is limited. Moreover, FAtiMA does not take the physiological aspects of emotion into account. Another problem with FAtiMA is the tedious authoring process of the character's goals, emotional reactions, actions and effects, and action tendencies so that the final behaviour of the characters is as intended. Having these values scripted reduces the dynamism of some of the core aspects modeled, resulting in agents that are not adaptive and do not learn from experience.

To address these constraints, we considered the PSI theory [20], a psychologically-founded theory that incorporates all the basic components of human action regulation: perception, motivation, cognition, memory, learning and emotions. It allows for modelling autonomous agents that adapt their internal representations to a dynamic environment. A few successes of the PSI model in replicating human behaviour in complex tasks can be found in [20, 24]. A PSI agent does not require any executive structure that conducts behaviour, rather, processes are self-regulatory and run in parallel driven by needs. Memory functions as a central basis for coordination.

Emotions within the PSI theory are conceptualised as specific modulations of cognitive and motivational processes enabling a wide range of empathic emotional effects. These modulations are realised by *emotional parameters*. *Arousal* is the preparedness for perception and reaction; *resolution level* determines the accuracy of cognitive processes; and *selection threshold* prevents oscillating between behaviours by giving the current intention priority. Different combinations of these parameter values lead to different physiological changes that resemble emotional experiences in biological agents. For example, if an event leads to a drop in the character's certainty, then its *arousal* level increases causing a decrease in the *resolution level*. In such situation, a quick reaction is required hence forbidding time-consuming search. The character will concentrate on the task in order to recover the deviated need(s) and hence may choose to carry out the first action that it found feasible. The character may be diagnosed as experiencing anxiety. Therefore, depending on the cognitive resources and the motivational state of the agent in a given situation, these parameters are adjusted, resulting in more or less careful or forceful ways of acting, as well as more or less deliberate cognitive processing.

Since, FAtiMA already includes perception, cognition, memory and emotions, we added the PSI motivational and learning components into the existing architecture. The motivational system serves as a quick adaptation mechanism of the agent to a specific situation and may lead to a change of belief about another agent as shown in [25], important for conflict resolution among ORIENT characters. PSI's other advantage over FAtiMA is that it does not require much authoring except initialising the agents with some prior knowledge. PSI agents' differences in behaviour will then correspond to different life-experiences that lead to different learned associations. Thus, PSI permits more flexibility both in authoring and the characters' behaviour than FAtiMA. Unfortunately, this also means lack of control over the characters' behaviour which is a problem because characters in ORIENT need to behave in certain ways so that the educational goal can be reached. According to [26], good educational games are games where narrative events situate the activity, constraining actions, provoking thought and sparking emotional responses. By making the NPCs react in certain ways, the player's ability to access information or manipulate the world is limited. This forces the player to evaluate the relative value of information and to devise appropriate goals and strategies to resolve complex authentic problems and help them to develop an experiential understanding of what might be otherwise an abstract principle.

Combining FAtiMA and PSI, the problems of psychological plausibility and control are addressed, neither of which can be solved by either architecture alone. Cultural and social aspects of interaction can be modelled using FAtiMA while PSI provides an adaptive mechanism for action regulation, fulfilling the requirements of ORIENT characters. Author are free to decide how much information they want to provide the characters to start with and leave the rest for the characters to learn. The degree of desirability (or undesirability) of an action or event is proportionate to the degree of positive (or negative) changes that an action or event brings to the agent's drives. This desirability value can be used to automatically generate emotions according to the OCC model, removing some of the need to write predefined domain-specific emotional reaction rules. This means that the reactive layer in FAtiMA may be omitted.

4.2 FAtiMA-PSI Architecture

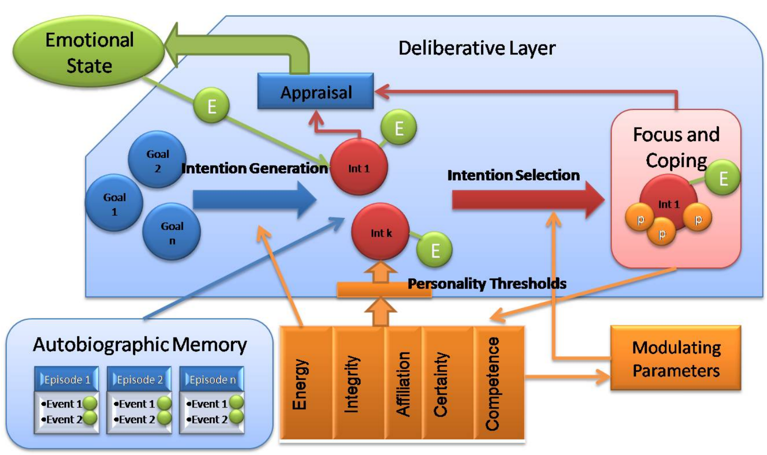

Fig. 1. FAtiMA-PSI architecture

In the ORIENT agent mind architecture shown in Figure 1, goals are driven by needs. A motivational system as in PSI provides the character with a basis for selective attention, critical for learning and memory processes, hence increases its adaptive prowess. Five basic drives from PSI are modeled in ORIENT including Energy, Integrity, Affiliation, Certainty and Competence. These needs can emerge over time or can be activated by events happening in the environment. Energy represents an overall need to preserve the existence of the agent (food +

water). As the agent carries out actions, it consumes energy which means that eventually, it will have to rest or perform actions to regain energy. Integrity represents well being, i.e. the agent avoids pain or physical damage while affiliation is useful for social relationships. On the other hand, certainty and competence influence cognitive processes. It is assumed that the scales for all drives are comparable, ranging from 0 to 10 where 0 means complete deprivation while 10 means complete satisfaction. An agent's aim is to maintain these drives at the highest level possible at all time in order to function properly.

The motivational system also allows the creation of agents with personality. Each drive has a specific weight ranging from 0 to 1 that underlines its importance to an agent. The strength of a drive (*Strength(d)*) depends on its current strength plus the amount of deviation from the set point (effect of goal/action) and the specific weight of the drive. For example, if agent A is a friendly character, affiliation would be an important factor in its social relations, say weight 0.8 while a hostile agent B would have a low importance for affiliation, say weight 0.3. Now, if both agents have a current affiliation value of 2 and if the deviation from set point is -4, agent A's strength for affiliation would be -1.2 (2+(-4*0.8)) while agent B's strength for affiliation would be 0.8 (2+(-4*0.3)) based on Equation 1. The higher the strength of a drive, the lower the agent's need is for that particular drive. In this case, agent A will work harder to satisfy its need for affiliation than agent B. So, by assigning different weights for different needs to different agents, characters with different personalities can be produced.

$$Strength(d) = Strength(d) + (Deviation(d) * Weight(d)) \tag{1}$$

A goal is define by the following attributes:

- Id: the goal identifier or name
- Preconditions: a list of conditions that determine when the goal becomes active
- SuccessConditions: a list of conditions used to determine if the goal is successful
- FailureConditions: a list of conditions that determine the goal failure
- EffectsOnDrives: specifies the effects that the goal will have on the agent's drives if the goal succeeds

Each goal contains information about its expected contribution to energy, integrity and affiliation, that is, how much the drives may be deviated from or satisfied if the goal is performed. Likewise, events or actions also include contributions to drives. Based on this information, the importance of goals to each character at a particular time instance can be determined, allowing the character to give priority to goals that satisfy its needs under different circumstances. This is an advantage over the previous FAtiMA architecture where a goal's importance is pre-authored which mean that whenever a goal activation condition becomes true, the goal is always created with the same importance of success and failure, independently of the situation that originated the goal. This causes a problem in deciding which goal should be selected when there are several conflicting goals. The effects of needs are also useful in the appraisal phase to create emotional impact that will be stored in the autobiographic memory and guide the agent's further actions. Since each agent has a different personality, the effect of an event may differ from one agent to another, which in turn affects their emotional and behavioural responses. Thus, needs can be considered both the source of behaviour and feedback from the effect of behaviour, a fundamental aspect necessary for learning agents.

As for certainty and competence, no explicit specification of contributions to these is necessary because they are cognitive needs and their values can be calculated automatically as described below. Whenever an expected event fails to turn up or an unknown object appears, the agent's certainty drops. Thus, uncertainty represents the extent to which knowledge about a given fact/action is not accurate or not known. We model uncertainty using error prediction with an Exponential Moving Average where the weighting factors decreases exponentially resulting in the lastest data being the most important. ORIENT characters continuously make predictions about the probability of success of their goals. These predictions are then compared with the actual outcomes. The difference between these two values is the *ObservedError*. Based on past observed errors, we can estimate the current error, that is, the current uncertainty using Equation 2. α represents the rate past observations lose importance and t is the time step for the character's mind cycle.

$$Uncertainty(t) = \alpha * ObservedError(t-1) + (1-\alpha) * Uncertainty(t-1) \quad (2)$$

Hence, gaining certainty is not about avoiding uncertain goals but trying out these goals. This is because in order to achieve certainty, the character has to reduce the estimation error, and the goals which have high error estimations are goals that contribute more to certainty. Certainty is achieved by exploration of new strategies or actions, which leads to the construction of more complete hypotheses. If trial and error is too dangerous, developments in the environment are observed in order to collect more information. By doing so, the character can change its behaviour dynamically. Please note that the character does not learn by forming new goals because this will lead to a lack of control over its behaviour. Instead, it learns by trying out different actions from a pre-specified set of actions and remembering which actions helped it to tackle a situation best. This information is stored in its autobiographic memory and serves as an indicator to the success probability of satisfying a specific need in future. Since certainty depends on the amount of unkown information relating to a goal, the more an agent encounters the same type of situation, the higher its certainty is regarding the situation.

Competence represents the efficiency of an agent in reaching its goals and fulfilling its demands. Success increases competence while failure decreases it. The agent's autobiographic memory provides a history of previous interactions, which records the agent's experience in a task (the number of successes in performing a goal) useful for the calculation of goal competence (likelihood of success in performing a goal, Equation 3). Since no distinction is made in calculating competence between achieving an important goal or a less important one, one can assume that all goals have the same contribution to the success rate. If the agent cannot remember previous activations of the goal, then it ignores the likelihood of success and increases the goal's contribution to certainty.

$$Comp(g) = NoOfSuccesses(g)/NoOfTries(g) \tag{3}$$

$$OverallComp = NoOfSuccesses/NoOfGoalsPerformed \tag{4}$$

The autobiographic memory also stores information about the agent's overall performance (the number of successes so far taking into consideration all goals performed) useful for the calculation of overall competence (Equation 4). The expected competence (Equation 5) of the agent will then be a sum of its overall competence and its competence in performing a current goal. A low competence level indicates that the agent should avoid taking risks and choose options that have worked well in the past. A high competence means that the agent can actively seek difficulties by experimenting with new courses of action that are less likely to succeed. Together, competence and certainty direct the agent towards explorative behavior; depending on its abilities and the difficulty of mastering the environment, it will actively seek novelty or avoid complexity. During this learning process, the agent also remembers any specific expressed emotions by other agents in particular situations. It continuously updates and adapts this information enabling empathic engagement in future interactions.

$$ExpComp(g) = OverallComp + Comp(g) \tag{5}$$

At the start of an interaction, each agent has a set of initial values for needs. Based on the level of its current needs, the agent generates intentions, that is, it activates goal(s) that are relevant to the perceived circumstances. A need may have several goals that satisfy it (e.g. I can gain affiliation by making a new friend or socialising with an old friend) and a goal can also affect more than one need (e.g. eating food offered by another agent satisfies the need for energy as well as affiliation). So, when determining a goal's strength (Equation 6), all drives that it satisfies are taken into account. A goal that satisfies more drives will have a higher strength than those that satisfy less.

$$Strength(g) = \sum Strength(d) \tag{6}$$

For a particular need, the more a goal reduces its deviation, the more important that goal is (e.g. eating a full carbohydrate meal when you're starving satisfies you better than eating a vegetarian salad). By looking at the contribution of the goal to overall needs and to a particular need, goals that satisfy the same need can be compared so that success rate in tackling the current circumstances can be maximised. So, the utility value of a goal can be determined taking into consideration overall goal strength on needs (*Strength(g)*), contribution of the goal to a particular need (*ExpCont(g, d)*) and the expected competence (*ExpComp(g)*) of the agent. Additionally, the urgency of a goal is taken into account. *Urgency(g)* gives importance to goals that should become active immediately, usually goals that satisfy the most current deviated need(s).

$$EU(g) = (1+goalUrgency(g))*ExpComp(g)*Strength(g)*ExpCont(g,d) \quad (7)$$

On each cycle, goals are checked to see if any has become active by testing the goal's preconditions. Once a goal becomes active, a new intention to achieve the goal is created and added to the intention structure. The intention represents the agent's commitment to achieve the goal and stores all plans created for it. Since there can be more than one intention activated at any particular time instance, the character must choose one of them to continue deliberation (and planning). Applying PSI, the selection of goal in ORIENT is performed based on the *selection threshold* value. The current active intention is selected based on a winner takes all approach, that is, the goal with the highest expected utility value is chosen. An unselected goal can be activated if its strength exceeds the value of the current active intention multiply by the *selection threshold*. So, if the *selection threshold* is high, it is less likely for another goal to be activated, hence, allowing the agent to concentrate on its current active intention. After an intention is selected, the agent proceeds to generate plan(s) to achieve it.

When a plan is brought into consideration by the reasoning process, it generates and updates OCC prospect based emotions such as:

- Hope: Hope to achieve the intention. The emotion intensity is determined from the goal's importance of success and the plan's probability of success.
- Fear: Fear of not being able to achieve the intention. The emotion intensity is determined from the goal's importance of failure and the plan's probability of failing.

All active goals are then checked to determine if the goal succeeds or fails. If the planner is unable to make a plan, more prospect based emotions will be generated, such as Satisfaction, Disappointment, Relief and Fears-Confirmed. In order to cope with different circumstances, ORIENT characters perform two types of coping: problem-focused coping and emotion-focused coping as in FAtiMA. Problem-focused coping focuses on acting on the environment to tackle a situation. It involves planning a set of actions that achieve a desired result and executing those actions. On the other hand, emotion-focused coping works by changing the agent's interpretation of circumstances, that is, lowering strong negative emotions for example, by lowering the importance of goals, a coping strategy used often by people when problem focused coping has low chances of success. These coping strategies are triggered by emotions and personality of the characters. For instance, a fearful character has a higher chance to drop an uncertain goal than a hopeful character.

5 Conclusion and Future Work

In this paper, we discussed our effort in developing autonomous NPCs for an educational role play game. In ORIENT, characters behaviour is regulated by a biologically-inpired architecture of human action regulation. The new addition of the motivational system onto FAtiMA provides ORIENT characters with a basis for selective attention, critical for learning and memory processes. Intentions are selected based on strength of activated needs, urgency and success probability addressing the BDI architecture ambiguity in decision making. The resulting agents learn through trial and error, allowing more efficient adaptation and empathic engagement in different social circumstances. The successful linking of body and mind is consistent with that of humans' and hence, should produce characters with behaviours that seem plausible to a human. The software which is written in Java has been made available at the open source portal SourceForge[5] and is reusable in autonomous agents applications.

Acknowledgements

This work was partially supported by European Commission (EC) and is currently funded by the eCIRCUS project IST-4-027656-STP with university partners Heriot-Watt, Hertfordshire, Sunderland, Warwick, Bamberg, Augsburg, Wuerzburg plus INESC-ID and Interagens. The authors are solely responsible for the content of this publication. It does not represent the opinion of the EC, and the EC is not responsible for any use that might be made of data appearing therein.

References

[1] Eck, R.V.: Digital game-based learning: It's not just the digital natives who are restless. EDUCAUSE Review **41**(2) (2006) 16–30

[2] Hogan, R.: Development of an empathy scale. Journal of Consulting and Clinical Psychology (35) (1977) 307–316

[3] Hoffman, M.L.: Empathy, its development and prosocial implications. Nebraska Symposium on Motivation **25** (1977) 169–217

[4] Ho, W.C., Dautenhahn, K., Nehaniv, C.L.: Computational memory architectures for autobiographic agents interacting in a complex virtual environment: A working model. Connection Science **20**(1) (2008) 21–65

[5] Cañamero, D.: A hormonal model of emotions for behavior control. In: VUB AI-Lab Memo 97-06, Vrije Universiteit Brussel, Belgium (1997)

[6] Velásquez, J.D.: Modeling emotions and other motivations in synthetic agents. In: Proceeding AAAI 97, AAAI Press and The MIT Press (1997) 10–15

[7] Blumberg, B.: Old Tricks, New Dogs: Ethology and Interactive Creatures. PhD thesis, Massachusetts Institute of Technology, MIT, Cambridge, MA (1996)

[8] Izard, C.E.: Four systems for emotion activation: Cognitive and noncognitive processes. Psychological Review **100**(1) (1993) 68–90

---

[5] http://sourceforge.net/projects/orient-ecircus

[9] Tomlinson, B., Blumberg, B.: Alphawolf: Social learning, emotion and development in autonomous virtual agents. First GSFC/JPL Workshop on Radical Agent Concepts (Oct, 04 2002)
[10] Ortony, A., Clore, G., Collins, A.: The cognitive structure of emotions. Cambridge University Press, Cambridge, UK (1988)
[11] Elliot, C.D.: The Affective Reasoner: A process model of emotions in an multi-agent system. PhD thesis, Northwestern University, Illinios (1992)
[12] Reilly, W.S., Bates, J.: Building emotional agents. Technical Report CMU-CS-91-143, School of Computer Science, Carnegie Mellon University (1992)
[13] Loyall, A.B., Bates, J.: Hap: A reactive adaptive architecture for agents. Technical Report CMU-CS-91-147, School of Computer Science, Carnegie Mellon University (1991)
[14] Gratch, J., Marsella, S.: Evaluating a computational model of emotion. Journal of Autonomous Agents and Multiagent Systems (Special issue on the best of AAMAS 2004) **11**(1) (2004) 23–43
[15] Dias, J., Paiva, A.: Feeling and reasoning: A computational model for emotional agents. In: 12th Portuguese Conference on Artificial Intelligence (EPIA 2005), Portugal, Springer (2005) 127–140
[16] Bratman, M.E.: Intention, Plans and Practical Reasoning. Harvard University Press, Cambridge, Massachusetts (1987)
[17] Sloman, A.: Varieties of affect and the cogaff architecture schema. In: Symposium on Emotion, Cognition and Affective Computing, AISB 01 Convention, University of York, United Kingdom (Mar, 21-24 2001)
[18] Randolph M. Jones, Amy E. Henninger, E.C.: Interfacing emotional behavior moderators with intelligent synthetic forces. In: Proceeding of the 11th CGF-BR Conference, Orlando, FL (May, 7 2002)
[19] Oliveira, E., Sarmento, L.: Emotional advantage for adaptability and autonomy. In: AAMAS, Melbourne, Australia, ACM (2003) 305–312
[20] Dörner, D.: The mathematics of emotions. In Frank Detje, D.D., Schaub, H., eds.: Proceedings of the Fifth International Conference on Cognitive Modeling, Bamberg, Germany (Apr, 10–12 2003) 75–79
[21] Damasio, A.: Descartes' Error: Emotion, Reason and the Human Brain. Gosset/Putnam Press, New York (1994)
[22] Aylett, R., Dias, J., Paiva, A.: An affectively driven planner for synthetic characters. In: International Conference on Automated Planning and Scheduling (ICAPS2006), UK (2006)
[23] Marsella, S., Johnson, B., LaBore, C.: Interactive pedagogical drama. In: Fourth International Conference on Autonomous Agents (AAMAS), Bologna, Italy, ACM Press (2002) 301–308
[24] Dörner, D., Gerdes, J., Mayer, M., Misra, S.: A simulation of cognitive and emotional effects of overcrowding. In: Proceedings of the 7th International Conference on Cognitive Modeling, Trieste, Italy (Apr, 5–8 2006)
[25] Lim, M.Y.: Emotions, Behaviour and Belief Regulation in An Intelligent Guide with Attitude. PhD thesis, School of Mathematical and Computer Sciences, Heriot-Watt University, Ediburgh, Edinburgh (2007)
[26] Squire, K.: Design principles of next generation digital gaming for education. Educational Technology **43**(5) (2003) 17–33 The Games-To-Teach Team at MIT.