An Affective Agent Framework Towards Believable Agents for Digital Entertainment

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Abstract. Digital entertainment industry uses multi-agents techniques based on several different approaches to establish autonomous characters that behave the most believable way as possible. This article presents a preliminary version of an agent architecture based on psychological and neurobiological theories. We expect that this architecture could facilitate implementation of synthetic believable characters by providing ways of defining different personalities for them while keeping the decision-making process evaluation time so short that allows its use in real-time applications.

1 Introduction

Digital storytelling is narrative entertainment that reaches its audience via digital technology and media [1]. Maybury et al [2] suggests a list of possible interactive digital entertainment applications and presents a set of artificial intelligence (AI) challenges in each of this areas: interactive games, interactive digital arts, interactive cinema, TV and radio, interactive digital sports, interactive travel and interactive education. To compete in the entertainment market, create quick and believable artificial agents (called nonplayer characters or NPC) has become a vital product differentiator [3].

By believable artificial agents we understand that agent's behavior will be as close as possible to human behavior in the same situation. To produce such believable experience, companies use AI multi-agents techniques [4] based on several different approaches.

Kline and Blumberg [5] suggests a short list of functional subsystems to an agent architecture in order to build synthetic characters:

Motivational Drives: a character must appear to take decisions in order to satisfying desires while gracefully handling unexpected situations.

Emotions: drives not only the characters' actions but also his motion (a sad character should walk differently then a fearful one).

Perception: in order the character's actions "make sense" to a viewer, he should have a way to understand the surrounding environment and use this information to make decisions.

Action Selection: uses AI planning techniques to decide for a 'plan' or sequence of actions using the information of the three previous subsystems to do that.

One approach that only recently has been used is simulation of human cognitive processes based on psychological theories which try to explain (in a computational manner) how humans make decisions. These theories are based (among other elements) on human personality.

The majority of psychologists accept that human personality can be described as five universal traits [6, 7]. However, according to Reiss theory [8], human motivation is guided by 16 basic desires: power, curiosity, independence, status, social contact, vengeance, honor, idealism, physical exercise, romance, family, order, eating, acceptance, tranquility and saving. And a character's personality could be represented as a set of weighted degrees of these desires.

In this work we propose an approach to believable agents (agents with personality) based on psychological and neurobiological theories such as the belief-desire theory of emotions and utility theory [9] for decision making process.

2 Psychological and Neurobiological Models

Psychology is a science focused on human (and animals) behaviors studies. Psychologist have been proposing theoretical models that try to explain several aspects of human behavior such as emotions, decision-making process and personality. These concepts will be useful to the understanding of the agent architecture proposed in section 3.1.

2.1 Emotions

The human brain (in order to simplification of understanding) can be separated in two main functions: the cortical system which is responsible for "higher" activities such as motor control and the limbic system responsible for emotions, memory and attention. According to Picard [10], emotion play a critical role in decision-making process, in perception, and in human intelligence.

Human decision-making is highly influenced by person's mood (emotions) and can not be disconsidered when it's trying to specify a computational model to human decision-making process [11].

Psychologists have been proposed several emotion models trying to explain human behavior. Next sections will briefly discuss two of them: OCC model and Belief-Desire Theory of Emotion.

OCC Model One of the most popular emotion theory between computer scientists, OCC model proposed by Ortony, Clore and Collins [12] defines emotions as valenced responses to environment events evaluated (by a subjective criteria) by the agent (the reason because this model become computationally popular is probably because it is easily implemented by a computer program [13]).

Besides OCC model be viable computationally (there are several successfull systems that was based on this model [14, 13, 15]), the number of necessary steps make this algorithm takes too much time for making a decision which is undesirable for real-time applications such as digital entertainment ones.

Belief-Desire Theory of Emotions (BDTE) The belief-desire theory of emotion presented in Reisenzein [16] suggests that "emotions are nonconceptual outputs (analog signals) of hardwired mechanisms whose primary function is to subserve the monitoring and updating of the central representational system of humans,the belief-desire system".

BDTE assumes that all emotions are products of cognitions (beliefs) and motives (desires), which means that they are reactions to "cognized" actual or potential fullfilment and frustations of desires plus confirmations or disconfirmations of beliefs.

To accomplish this the author proposed an agent architecture based on four main modules: belief store, desire store, belief-belief comparator (BBC) and belief-desire comparator (BDC). The author affirms that the BBC and BDC mechanisms are not learned procedures, but hardwired into the brain, and they operate continuously on a preconscious level to produce analog signals that vary only in kind and intensity (called emotions).

2.2 Decision-Making Process

There are several theories for autonomous decision making, such as: expected utility theory, prospect theory and more recently fast and frugal theory (bounded rationality):

Expected Utility Theory: models decision making under uncertainty through a function (called *utility* [9]) $E(U) = \sum_{i=1}^{n} U(W_i)p_i$, where p_i is the probability of a given outcome i occurs and W_i is a wealth given by the decision maker if a particular outcome i is realized. For a given set of outcomes the one with a *maximum expected utility (MEU)* is choosen and executed.

Prospect Theory: models decisions under risk are made in two stages [17]: *editing* produces a list of possible outcomes through heuristics classifying each one in `gains` or `losses` and then in the *evaluation* stage an utility function decide for a particular outcome.

Fast and Frugal Theory: Consists of step-by-step heuristic rules for decision under constraints of search, knowledge and time [18, 11]. This set of rules are specified for guiding search for information, for stopping search and for decision making.

2.3 Personality

Been able to incorporate personality in artificial intelligent agents is one of the most important activities in order to achieve believability. That's because is exactly personality that dictates how humans behave in a socially acceptable way even in a dynamic environment.

Prendinger et al [19] defines personality as patterns of thought, attitude, and behavior that are permanent or at least change very slowly. The majority of psychologists accept that human personality can be described as five universal traits [6, 7]: extroversion, agreeableness (or sociability), conscientiousness, neuroticism and oppeness to experience (also called intellect or culture).

Several computational models have been proposed to incorporate personality in affective agents. Dias and Paiva [13] proposes an agent architecture based on OCC model [12]. Their character's personalities are defined by: a set of goals; a set of emotional rules; character's action tendencies; emotional thresholds and decay rates of each of the 22 emotion types (from OCC model). Their architecture is based on two main layers: the reactive layer is responsible for character's action tendencies and the deliberative layer is responsible for agent's behavior.

In Thalmann et al [20], based on two personality model: OCEAN model [21] which is a five dimensional model and the three-dimensional PEN model [22], the authors suggests the idea of a generic multidimensional personality model (see eq. 1):

$$p^T = [\alpha_1 \ldots \alpha_n], \forall i \in [1, n] : \alpha_i \in [0, 1] \tag{1}$$

Inspired on this works and on Reiss theory [8], human motivation is guided by 16 basic desires: power, curiosity, independence, status, social contact, vengeance, honor, idealism, physical exercise, romance, family, order, eating, acceptance, tranquility and saving. So, a character's personality is a 16D set of weighted degrees of these desires.

3 PhD Proposal

The hypothesis of this research is that an affect-based multi-agent framework can be a robust method to be used in digital entertainment by providing a set of characteristics such as the one presented by Dias and Paiva [13], in order to achieve believable characters which are synthetic characters that behave just like humans in the same situation.

3.1 Proposed Architecture

We propose an object-oriented framework based on belief-desire theory of emotions and utility theory, which is inspired on the architectures proposed in [23, 24, 13]. Our architecture is composed by the following modules (see Figure 1):

The Perception module is composed by all sensors the agent have (vision, earing, etc). It is responsible for getting events from the surrounding environment

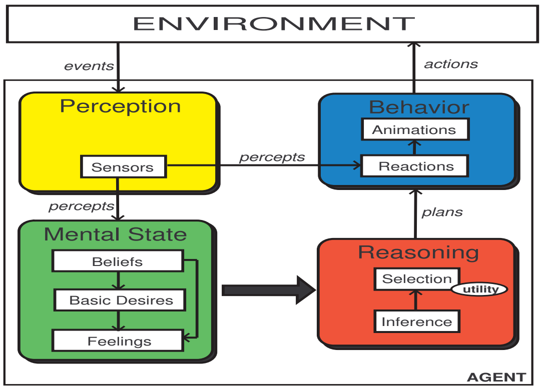

Fig. 1. Proposed Architecture

(or from internal reactions) and transforming them into percepts (events with semantic meaning). For instance, if the agent perceives an explosion, he can generate two percepts (one visual and other sound) and agregate information about each one such as the location of the event, intensity and so on. All detected percepts will be passed to the Mental State module (beliefs + basic desires + feelings) and to the Reactions module.

The Beliefs module (which corresponds to the agent's memory) stores the agent's representation of the environment such as maps, percepts, etc. This information is then used in the next two modules: the Basic Desires module and the Feelings module. The Basic Desires module specifies the agent's personality through a list of weighted basic desires (for instance, how curious the agent is about a certain percept). If an agent has a basic desire and a given percept produces a contradictory belief, it will produce (in the agent's feelings module) a resulting negative feeling (disappointment). The set of values of each of these agent's properties (beliefs + basic desires + feelings) represents the agent's mental state which will command (determine?) the execution of the next module: the Reasoning module.

The Reasoning module is responsible for deciding a sequence of actions. This is accomplished in two stages: in the inference phase, the agent tries to answer the question: 'what can the agent do about the current mental states?'. The result is a list of possible actions. Then, the selection module takes place specifying an order to this list. Our proposed architecture will do this through expected utility theory, by calculating an utility value for each action (from an objective criteria such as probability of success). This architecture is designed in such a way that it easily allows the substitution of this selection module for other ones based for instance on prospect theory, etc allowing different selection criterias.

After a plan is produced, it is time to execute it. This is the job of the Behavior module, which comprises the Reactions module and Animations module. The former is responsible for determining possible instant reactions in a deterministic way by using finite states machines (FSM), rule based systems (RBS) or case based reasoning (CBR). The later is responsible for exhibiting each action in the environment as a predefined animation.

In order to make more clear how the proposed architecture works a practical example of its use follows: an agent with low energy level, which could be understood as a desire for 'eating', will start looking for a restaurant in the environment (because he assumes the beliefs that there he will stop feel hungry); however, if the restaurant is closed when he finds it, this change in the agent's beliefs produces new feelings (in this case frustration) which will lead him to take particular actions based on his own personality (for instance, seat and cry in front of the building or try to force his entrance). Eventually he could decide to find a new source of food or die from starvation.

3.2 Expected Results

We expect that our framework will allow the creation of believable characters for digital entertainment in a faster and easier manner, reducing the animator's work to the specification of the agent's personalities (instead of programming all behaviors).

3.3 Evaluation

The expectation is that our proposed architecture could facilitate implementation of synthetic believable characters on a way that the decision-making process could be evaluated in a so short time that it yields its use in real-time systems. Also we expect that the framework could be applied on different digital entertainment applications. After the implementation phase, we propose the following approaches to evaluate the possible results:

- To evaluate if this framework really facilitates implementation of NPC's in different digital entertainment domains, we are proposing three possible case studies: a multi player game, an interactive storytelling system and a virtual creature environment. These applications were chosen because we believe that they represent different scenarios where a NPC can take place. In a computer game, quick NPC's decisions making and actions are a vital characteristic. In interactive storytelling, the agent could be capable of interpreting users commands in the same way an actor responds to the director's guidelines (performance is important but some fail actions are supported and even expected). And a virtual creature (like a virtual pet), which is some kind of artificial life simulation, that could (only through his actions) express their emotional state to the audience.
- To compare our framework with commonly used frameworks. This comparison should essentially focus on believability, including response time and accurate emotional behavior. This test is strongly dependent on the possibility of having access to such frameworks, which may not be easy giving the commercial nature of most of them.

– To evaluate if the characters really promote believable experiences, we are planning to develop a questionnaire to submit to the audience. After some time using the environment, users will be asked for their impressions about the NPC's. Could a NPC's promote the illusion of life through his behavior?

4 Discussion

Creation of believable NPC's is an important (however difficult) task to accomplish in digital entertainment programming. One possible technique that has been recently used is the simulation of human cognitive decision making process. This article presented a brief overview about possible digital entertainment areas that could be improved by this approach. Some different psychological theories based on cognition and emotion try to explain how humans think and make decisions.

BDTE suggests that emotions are products (analog signals) of cognitions (beliefs) and motives (desires). Once one emotion can be simulated by a computer agent, this information could be used in the utility theory (decision making module of the agent) to define a plan to achieve a specific goal in the environment where the agent is immersed. In our approach, the agent personality can be simulated by a set of weighted degrees of 16 basic desires so this, influencing how an agent will behave in a particular situation.

Although these theories have been already used in several successful applications, as far as we noticed it will be the first time that these combined approaches (BDTE + utility theory) will be tried in a digital entertainment context.

The expectation is that this proposed architecture will facilitate implementation of synthetic believable characters on a way that the decision-making process could be evaluated in a so short time that allows its use in real-time applications.

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