# **Evolutive Autonomous Behaviors for Agents System in Serious Games**

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Abstract—This article describes how to generate autonomous behavior to populate a virtual environment using Serious Games and Learning Classifier Systems. A serious game is a paradigm that simulates the real environment like a natural phenomenon. For example, people's behavior living an earthquake, fire, weather phenomenon or others. Into a serious game, the users are represented by virtual entities that have autonomous behavior taken from human's behavior. The principal interest to use serious games is that it's possible to obtain a tool with capabilities to predict, to plan and to train people involved in many natural phenomenons. The originality of this paper is that used a Learning Classifier Systems (LCS) inside in Serious games. It is possible to find a better simulation of the human's behavior into a real situation, using learning machine. The entities (agents) has autonomy and adaptability given by a genetic algorithm embedded in the LCS.

Key words: Agents's Behavior, Artificial Intelligence, Virtual Environments, Serious Games, LCS, Learning Machine.

### 1. Introduction

Today, computer-based systems support the different activities of human, beginning from productive tasks until tasks of leisure. One of the most active areas of computer systems is Immersive Virtual Reality Systems. That is virtual environments where users interact with the environment using possibly specific interfaces like gloves, head-mounted displays, virtual sensors, etc. Human imagination only limits the applications of this technology. Currently, using this technology, we can do virtual visit to museums, factories, research centers, etc. However, one of the presents problems in this technology is the creation of realistic virtual environments.

In this paper, we are interested in the creation of realistic behavior using in scenarios where agents act in natural form but were the evolution of the agents is important. Model tools are used to satisfy this requirement. However, solutions using this approach are complex and very costly, mainly when the objective is the simulation of the evolution of a virtual world.

In our case, the humans are embed in a social environment, a social environment system is a set of individuals that interact mutually to the artifacts from its environment. The agents needed to recreate the social behavior, in fact, the agent evolves accorded to their belief, desire and intentions.

Serious games are an actual paradigm to recreate the real phenomenon that common people are living. The principal interest to recreate the real environment is to can predict a situation where the user's integrity can be affected by the external phenomenons. A clear example was the influenza pandemic, where Mexico had affected in 2008 leaving considerable damages in the population and the official organizations.

Computer Science, in particular, Artificial Intelligence, proposes methods to generate autonomous behavior to collaborates disciplinary with human behavior areas, thus, help to understand social behavior in individual that interact with the environment. The Multi-Agent Systems (MAS) are the representation of a virtual entity. These systems try to copy the social behavior similar to individual in real world [1];

The knowledge initial of agents is taken on goal in



concordance to desires, beliefs and intentions grouped to create autonomy. The LCS grants the possibility to evolve into the environment by itself, characteristics of communication and collaboration emerge in agents to meet your goals like observed in human society.

This article shows the way to create intelligent agents with autonomous social behavior to develop serious games, where phenomenon in daily life is shown. Serious games are a tool to predict not controlled events. In section 2 we presents the definition of an intelligent Agents, section 3 describe the Learning Classifier System and our proposal architecture, section 4 presents the development our proposal architecture and finally section 5 and 6 presents the results obtained with our proposal architecture and the conclusion, respectly.

#### 2. Intelligent Agents

Intelligent Agent is an entity capable of perceiving its environment, processing such perceptions and to response or action in your environment in a rational manner [2]. In other words, Intelligent Agent gets the best performance to maximize the answer desired. Figure 1 represents the basic architecture of an agent and the ability to act autonomously in an environment. Therefore, an agent is an entity able to take their decisions about how to act in your environment, where there is no influence of a leader or a global plan.



Figure 1. Architecture based on an intelligent agent

An intelligent agent has a behaviour; it's can go from the complex action of the human or animal's behaviour based on their instinct or desired [4]. An agent must be autonomous, reactive, proactive and social. Their characteristics be mention below:

- Autonomous: Agents have to operate without human intervention on their actions and decisions.
- Reactive: Agents can feel the change of the environment and to adapt at them.
- Proactive: Agents can focus on their actions and decisions to achieve their objectives.
- Social: Agents can communicate with them.

The characteristics of an agent are not more than an architecture that can be using, as a particular methodology for its construction. An agent has multiples components that interact with them to define the internal characteristics of the state of the agent. An architecture covers both technical and algorithms that support this methodology. Consequently, an architecture depends on the objectives, the tasks to be carried out and the environment [5].

In other words, an agent can have many components that interact to define the state of its internal characteristics. Architecture covers techniques and algorithms that support this methodology. As a consequence, architecture depends on environment; goals and tasks that have to be done [5].

In our case, we will use architectures based on BDI (Belief-Desire -Intention). This type of architectures takes decisions through a process of reasoning, which starts with the beliefs of the world and desires that the agent seeks to achieve. The intentions are building as a result of the beliefs and desires.

#### 3. Learning Classifier System

The LCS is a powerful learning machine that uses ambient conditions to suit the objectives and achieve this through an evolutionary mechanism that allows find new solutions to help meet complex tasks [12].

The agent must learn from its environment, and take actions to react in some situations that can have unexpected events. Classifier systems can help giving tools on artificial life processes and will be used in our work because we want to simulate different behaviors on the environment. The LCS general structure is shown in Figure 2.



Figure 2. LCS general structure

A classifier has three parts: condition, action and weight. These are described below:

**condition**: the condition is a situation of an environment, and the captors sense this condition then its matches with

the base of classifiers; the best classifier is the winner to respond to a given situation.

**action** is the element that respond to a situation of the environment and modify this to a new situation.

**weight** is activated when there is more than one classifier that respond a situation of the environment, so, it activates the rule with higher weight using genetics algorithms. The rules are updating its status with different weights, so, worst rules are eliminated, and the environment can adapt itself to better rules.

In dynamic environments, the response to several situations should be fast, and then it is necessary to use mechanisms of prediction, correct classifiers have the same value and same changes to be selected. LCS most used as a Q-learning learning system [3]. With this advantage, all the status from the environment is saved updating the prediction of the classifiers to get a complete panorama to the environment. Q-learning is a process that helps to update the prediction of the classifiers from the previous step  $p_{[A]i-1}$ . Q-learning uses the previous rewards [Pi-1] and the predictions. The equation (1) shows the mechanism to insert many classifiers, as much as we need to simulate a complex environment.

$$p_{[A]i-1} = [Pi-1] + \gamma MAX(p_{[A]})wiht(0 \le \gamma \le 1)$$
(1)

Update the prediction of the next state in the environment is over-taken by the dynamics of the environment that necessitates the creation of new classifiers using a genetic algorithm.

The nature of the construction of the initial population of the genetic algorithm is a direct transition from the representation of the situation of the environment which makes the system evolutionary completely.



Figure 3. construction of classifier in LCS

The Figure 3 shows the construction of a binary classifier, this is the easiest way to creation, but not the best. We use a representation of the condition of the environment with abstract data.

### 4. Development

BDI model [7] is conceived as Practical Human Reasoning Theory, this model supports events based on reactive and proactive behavior or behavior to reach goals, this is a benefit of this model when is needed to implement Serious games. Figure 4 shows BDI model.



Figure 4. BDI Architecture model

Beliefs inform system status that represent information that an agent has about its environment and its internal status. Thus, desires are agents motivational status used to reach its goals. Finally, intentions help to take decisions about plans that are made to reach goals. However, a plan is not necessary a part of basic facts, the plan can include sub-goals.

Serious games take importance since the user has to be aided with a task. This task can be from an educative assistant to a training complex system to maintain an airplane turbine. Serious games contain entities that help the user and give knowledge to the user. Entities behavior must be as real as possible to make user feels attracted by the serious game all the time.

Figure 5 shows an environment based on a virtual city using Unity 3D. This city has main items for simulating agents as pedestrians.

Agents that pollute the environment are based on LCS and BDI model as follows:

•  $\theta$  is a set that describes the agents environment.



Figure 5. Environment in a virtual city

•  $T(\theta)$  is a set of attributes  $\{\tau 1, \tau 2 \dots \tau n\}$  describes the environment

**Definition 1:** A belief c over  $\theta$  is a n-tuple of  $T(\theta)$  attributes. It is referred as  $c = ((\tau 1, \tau 2, ..., \tau m)$  with  $m \leq n$ .

**Definition 2:** A set of beliefs over  $\theta$  as  $C(\theta) = \{(\tau 1, \tau 2, \tau m) \text{ where } j = 1, 2, ..., m \le n\}$ 

Example: Assumption that  $T(\theta)$  includes all attributes needed to characterize a touristic path in Salamanca city.

 $T(\theta) = \{\tau 1 = \text{monument's}, \tau 2 = \text{schedule}, \tau 3 = \text{cost}, \tau 4 = \text{travelling time}, ..., \tau n\}$ 

In this environment a belief, for example, monument, is an attribute vector of  $T(\theta)$  that belongs to monument

Belief monument = { $\tau 1$  = monument's,  $\tau 2$  = schedule,  $\tau 3$  = cost,  $\tau 4$  = quality indicator}

**Definition 3:** Being  $\land$  an accessibility operator between m beliefs defined as  $(c1, c2, c3, ..., cm) \land (c1, c2, c3, ..., cm) = (c1 \land c2 \land ..., cm)$ , this is the operator to create new structures joining beliefs that supports each other.

 $\wedge$  operator is null over beliefs if some of them is not accessible and it is denoted by  $\wedge(c1, c2, c3, ..., cm) = 0$ .

**Definition 4:** An intention *i* over is a s-tuple of beliefs each other compatible and is denoted by i = (c1, c2, ..., cs)with  $s \in N$ ,  $\land (ci, cj) \neq 0$ .

**Definition 5:** Set of intentions over  $\theta$ , is defined by  $I(\theta) = \{(c1, c2, ..., ck) \text{ where } k \in N\}$ 

**Definition 6:** Canonical variables of a set are any set  $I(\theta)$  of independent linear parameters  $\chi = (A_1, A_2, ..., A_v)$  that characterize  $i \in I(\theta)$  items. These variables are part of each problem P given.

**Definition 7:** A desire d over  $\tau$  is a function defined by

$$d: \mathbf{I}(\theta) \to \Omega(\chi)$$

 $i = (c1 \land ... \land cr \rightarrow F(A_1, A_2, ..., A_v)$ 

where  $\Omega(\chi)$  is a function set over  $\chi$ 

The expression above refers to intentional attitudes that we call desires. These desires can be achieved through a plan to this effect, in other words, all information that beliefs give us are evaluated taking parameters related to desired goals.

**Definition 8:** A set of desires over  $\theta$  is defined as

 $D(\theta) = \{ d: \mathbf{I}(\theta) \to \Omega(\chi) \}$ 

Where  $I(\theta)$  are intentions and  $\Omega(\chi)$  are functions over  $\chi$ .

#### 5. Results

To watch physical and natural phenomenon like human watch them in his real world is a wide problem. Serious games have a virtual environment to simulate this phenomenon. Castle [8] said that a virtual environment is a way to do simulations of activities from real world thru time, this is done to understand its behavior and evaluate new possibilities.

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To this article, we used an LCS and BDI architecture for creating a Systeme Multi-Agents to pedestrian simulation in a city for watching agents behavior and how agents modify the internal states to reach their goals. Movement of agents is based on vehicle concept proposed by Reynolds [10]. So, is possible to find autonomous agents with movements made in three layers: I) Choose action, II) Direction and III) Locomotion. These layers are described below:

I) Choose an action: Agent has one or more goals, so, it can select one or more actions to reach its goals. (For example, communicate with other agents, avoid an obstacle, take a route, etc.). First of all, an agent will broker its environment and later, it will take an action based on a desire.

II) Direction: After the action was chosen, the agent has to do next movement under a direction force.

III) Locomotion: This layer sometimes is not considered because is related with agents body movement.

Figure 6 shows hierarchy between layers described above:



Figure 6. Hierarchy of movement behavior

Figure 7 shows an agent embedded in a virtual city. On this stage, a maquette is used to simulate the environment for validating agents behaviors.

Agents can walk on the blocks, visit attraction parks, avoid obstacles, and overall, have knowledge of pedestrian zone, such as sidewalks, corridors, etc. Agents have to go to corners and wait till traffic light is green for crossing streets. On this stage our virtual environment doesn't have cars, it will be included later.



Figure 7. Agent embedded on a virtual environment

The Figure 8 shows an agent called Jazmin, she has to walk thru a virtual city, if she wishes, she can go inside of a building, only if this building is available. Non-specific characteristic blocks compound the virtual environment, but it will contain doors that can be open, access to buildings, etc.



Figure 8. Agent Jazmin walking thru virtual city

LCS architecture and BDI paradigm let us watch autonomous behavior, even though architecture can change depending on the autonomous action that we want to represent or study.

#### 6. Conclusion

Serious games are an efficient tool to watch interesting phenomenon in different society areas and productive sectors thru real environment simulations.

LCS shows high reactivity in the environment, which allows us to observe behavior in the most natural agents, according to the ambient pressure.

The BDI model allows agents to have an initial knowledge base upon the simulation and can be observed behaviors encouraged if not based on tasks and objectives to be achieved in the environment.

The possibility to change the agent's knowledge base to implement an adaptive process with real autonomy in entities that integrate virtual environment. We have to generate behavior based on emotions created by virtual agents, just to study the social phenomenon and another kind of behavior.

In this first stage, we have an SMA that aim to walk in the street of the city to stop at some point if there is a change of attention, for example, see a sideboard.

We currently work in more complex behaviors for a disaster such as an earthquake.

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