A Motivation-Based Mechanism to Design Behaviors

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Abstract. In human-level simulations, like video games can be, the design of character's behaviors has an important impact on simulation realism. We propose to divide it into a *reasoning* part, dedicated to a planner, and an *individuality* part, assigned to an action selection mechanism. Applying the separation of declarative and procedural aspects, the principle is to provide every character with the same procedural mechanisms: the planner and the action selection mechanism. Declarative knowledge is then used at the agent level to individualize the behavior. The contribution of this paper consists in a motivation-based action selection mechanism that allows individualization in behavior. The modularity provided by the motivations enables a large variety of behaviors for which the designer has to choose parameters. If the simulation of characters are our first motivation, the principles involved in the proposed motivation-based action mechanism are general enough to be used in other contexts.

1 Introduction

The construction of believable NPC behavior enhances the playability of video games, as well as the interest of the players since immersion is increased. This paper considers this problem and makes a proposition that allows to achieve the design of various behaviors.

The behavior of an agent is the result of the sequence of actions that the agent performs in its environment. With the notion of agent behavior, not only comes the observation of the actions that the agent undertakes but an appreciation of the personality of the agent is made too.

The behavioral psychological theory developed by Albert Burloud states that the behavior is influenced (positively or negatively) by **tendencies**. A tendency can express *neutrality*, if it has no influence on the behavior, *attraction*, if it drives the behavior to do something, *repulsion*, if it tends to divert the behavior from doing something and *inhibition*, if it prevents absolutely the behavior to do something.

The observable behavior of an agent depends on the actions it can perform, i.e. its abilities. To solve a goal, an agent builds a plan based on its abilities (and its knowledge). From this plan an action is selected and performed by the agent. Hence, the behavior results from a sequence of choices. Then, two elements, which influence the behavior, appear: first, the way the plan is built and, second, the way this particular action is chosen among others. Therefore the behavior building, and by way of consequence the work of a behavior designer, can be split in two distinct sequential parts. We call these parts **reasoning** and **individuality**.

The **reasoning** corresponds to the part that consists in computing the possible solutions for solving goals according to agent's abilities and knowledge. This task is usually assigned to a *planner*. The planner computes all the possible plans at a given time and thus determines the runnable actions, ie. the actions which conditions are satisfied by the current context. We want plans to be described as a sequence of actions without disjunction and we use the term of **alternative** to refer to such plans. An alternative is then a triple $(g, \alpha, (a_i)_{i\in[1,n]})$ where g is a goal, α is a runnable action and $\forall i \in [1, n], a_i$ is an action and $(\alpha, a_1, \ldots, a_n)$ is a sequence of actions to achieve g. Our proposition is that this reasoning be the same for all the agents.

The **individuality** part follows the reasoning. Its task is to select an action from the possible solutions computed by the reasoning. It is assigned to an *action selection mechanism* (ASM for short) which selects the action that is going to be actually performed by the agent. The proposition we developed is an action selection mechanism based on motivations.The evaluation of the motivations being different from one agent to another, they are the way to distinguish agent's behaviors and to add personality traits to the agent's behavior. In our proposition, two agents with the same abilities and knowledge would produce the same reasoning but can nevertheless behave differently thanks to this action selection mechanism which enables to express their individualities.

The reasonning and individuality procedural mechanisms are then the same for every agent. The abilities and motivations can be declared for every agent. They can differ from one agent to the other achieving the separation of procedural and declarative aspects.

Responsibility of each part is clear. Actually, the reasoning part is dedicated to the solving of agent's goals, and individuality part is dedicated to the problem of choosing the next action to be performed. Our contribution does not carry on the reasonning part, there exists a lot of works on planners, but it carries on the individuality part and we propose a motivation-based action selection mechanism.

2 A Motivation-Based ASM for Individuality

While the reasoning part tries to solve the goals, the role of the individuality part is to select the next action to be performed by the agent. This task is carried out by action selection mechanism. In this purpose, an ASM assigns to each runnable action (identified by the reasonning engine) a numeric value and selects action with the greatest value.

Definition 1 (Action Selection Mechanism) *Let $\mathcal{A}$ be the set of actions, and ϕ a function:*

$$\phi: \begin{array}{ccc} \mathcal{A} & \rightarrow & \mathbb{R} \\ a & \mapsto & value \end{array}$$

*then the **action selection mechanism** is defined as the application:*

$$ASM: \begin{array}{ccc} \mathcal{P}(\mathcal{A}) & \rightarrow & \mathcal{A} \\ \mathcal{A}^R & \mapsto & \arg\max_{a\in\mathcal{A}^R}(\phi(a)) \end{array}$$

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Our contribution consists in the definition of the function ϕ of Definition 1. We claim that the behavior is influenced by tendencies computed from motivations [2]. Then, we propose to define ϕ as the function that combines these influences, each motivation being expressed through a function that we called **evaluator**. Thus, an evaluator provides a rating for each runnable action, expressing influence of the motivation on this runnable action (like an advisor in [3]).

Definition 2 *Let $\mathcal{A}lt$ be the set of all alternatives. A* ***motivation*** *is defined by a function γ, called* ***evaluator****:*

$$\begin{array}{lccc} \gamma: & \mathcal{A}lt & \rightarrow & \mathbb{R} \\ & alt = (g, \alpha, (a_i)_{i\in[1,p]}) & \mapsto & r \end{array}$$

Then let $\mathcal{A}lt$ be the set of all possible alternatives, a ***motivation based action selection mechanism*** *is a pair $(Comb, \Gamma)$ where $Comb$ is a combination function from $\mathbb{R}^n$ to $\mathbb{R}$ and $\Gamma = \{\gamma_1, \ldots, \gamma_n\}$ is a set of motivations. Then, the function ϕ can be defined by:*

$$\begin{array}{lccc} \phi: & \mathcal{A}lt & \rightarrow & \mathbb{R} \\ & alt & \mapsto & Comb(\gamma_1(alt), \cdots, \gamma_n(alt)) \end{array}$$

and a motivation based ASM is defined as the application:

$$\begin{array}{lccc} ASM: & \mathcal{P}(\mathcal{A}lt) & \rightarrow & \mathcal{A} \\ & \mathcal{A}lt_i & \mapsto & \alpha \end{array}$$

where α is the runnable action of an alternative alt such that, $alt = (g, \alpha, (a_i)_{[1,p]}) = \arg\max_{alt\in\mathcal{A}^R}(\phi(alt))$.

3 Behavior design with the motivation-based ASM

The behavior designer has first to define the motivation based ASM. It can be done once for all the agents and this task can be divided in three stages. First, the identification of all the desired and relevant motivations, i.e. the set Γ, must be achieved. The motivations are independent from each other. Second, the combination function $Comb$ to be used must be chosen. Third, for each motivation in Γ an evaluator γ_i must be defined.

The first step is rather conceptual. It is the problem of determining the general motivations that should drive the agent behavior. A good principle to follow is to separate motivations such that the role of each can be easily and clearly expressed. A good expression of the motivation role eases the evaluator definition at third step.

In the second step the combination function is chosen. Each motivation gives its "advice" on runnable actions. The role of the combining function is to aggregate these evaluations in order to obtain a general evaluation (like a global welfare in a collective decision [1]). The combination function has to respect the two criteria. First, it must enable motivations to express neutrality, repulsion, attraction and inhibition. Second, since motivation are independent, it must enable the adding and removal of motivations while keeping the consistency of aggregation with respect to the individuality. The respect of this second criteria implies that it is possible to incrementally build the ASM. In this case, a posteriori required new motivations can be added, without questioning what has already be done, even and especially concerning the agent individuality level. This is an important property that increases the ASM robustness. Let us note that the choice of the combination function constraints and influences the evaluators domain and range. These must be precise at this step as well.

The main difficulty lies probably in the third step where the chosen motivations must be translated into a function. But one must keep in mind, that there will be several concurrent motivations, therefore the notion of "tendency" is important, the evaluator has to make the action selection to tip in the wished tendency, and not to define precisely the chosen action. Moreover, the designer has to be watchful to build motivations that take into account the three parts of the alternatives: the goals, the runnable action and the other-actions sequence. Every motivation does not need to tackle the three parts, even if some can, but the three parts must be considered at the moment or the other.

Following these steps we have designed a specific ASM for character's agent acting in simulated environments, like are role-playing video games. The simulation designer provides the agents with abilities. The agents have goals and use their abilities to solve them, and thus they act in the environment and interact with other entities of the simulation. The ASM we designed considers five *personal* motivations and two *environmental* motivations. Personal motivations are: the *goal influence* that takes into account the different goals and their priorities; the *agent preferences* motivation favours or penalizes the actions the agent likes or dislikes ; the *achievement in time* that favors alternatives whose achievement requires the less time; the *momentum* whose purpose is to prevent too many changes, or oscillations, in agent's behavior ; *the multi-goal revaluation* that promotes runnable actions which contribute to several goals. Environmental motivations are the *opportunism* that promotes a runnable actions if it involves a target that is close enough and the *achievement in space* that favors alternatives that requires less move steps to be achieve.

For each of these motivations, behavior profiles can be defined. They correspond to elementary behavior prototypes that exhibits some individuality features. These prototypes can then be combined to obtain various richer behaviors. This task corresponds to a second level of work for the behavior designer. For every agent, the designer has to determine the appropriate combination that corresponds to the desired behavior.

4 Conclusion

The design of character behavior is a complex task. Applying the separation of declarative and procedural aspects, we propose to provide every character with the same procedural mechanisms: the planner and the action selection mechanism. The difference between the behaviors of agents are then due to differences in their abilities and behavior profiles parameters. The core of our proposition is based on our motivation-based action selection mechanism that enables behaviors' individualization. The modularity provided by the motivations enables a large variety of behaviors for which the designer has to instanciate parameters. The behavior designer can rely on previously defined parameter sets and combine them. We propose a methodological approach in order to design the behaviors following this principle. One consequence is that, once some "core" designer has identified the tendencies that influence the behavior, how they combine and how each tendency is computed, no a priori knowledge in AI is required. A "final" behavior designer can then work to tune a character behavior as needed.

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