COBAI : A Generic Agent-Based Model of Human Behaviors Centered on Contexts and Interactions

Extended Abstract

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ABSTRACT

This paper presents a generic agent-based model for human behaviors in simulations. COBAI (Context-Based Agent Interactions) is based on a previous model featuring contexts as a source of behaviors. We kept the base principles of this model. Agents cannot act alone: contexts give them behaviors to adopt. Agents can be influenced by several contexts and choose behaviors to adopt. Agents possess character attributes that adjust this choice. This mechanism results in the ability to control realism both at the level of individual agents and groups of agents. The previous model presented some limitations. For instance, a behavior could only result from a single context, limiting the variety and realism of behaviors. This paper presents a new model with features addressing this issue. We present a new behavior selection architecture, allowing the execution of several simultaneous behaviors and behaviors resulting from a combination of contexts. We introduce the new concepts of resources, skills, tools, modalities, and incomplete behaviors. Using this new architecture, we define groups of agents with task distribution. We apply the model to a case study of an emergency crisis developed in Unity.

KEYWORDS

Simulation; agent-based system; behavior simulation; agent interactions

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1 INTRODUCTION

Context plays an essential role in human behaviors and interactions with their environment. Thus, context became a topic of research interest in artificial intelligence. As agent-based systems became popular for microscopic human behavior simulation, some researchers have explored using contexts to influence agent behaviors. There is a wide variety of context representations, like contextual schemas in CMB (Context-Mediated Behaviors) [13], context-based reasoning applied to agent-based systems [2, 5, 9, 10], context filters in EASI (Environment as Active Support of Interaction) [11] and EASS (Environment as Active Support for Simulation) used more recently [1]. There is no universal definition of context. The main idea is to include contextual information, that is, information that depends on variables like location, time, or environment points of interest.

In line with this movement, Soussi and Savelli introduced in 2009 a model based on contexts (later referred to as the context-based model) [12] and character attributes. The main idea of the model can be compared to affordance as defined by Gibson [4], still used in recent research [6–8]. This model achieves realism of behavior at the individual level by using character attributes while controlling groups of agents with context force, resulting in realistic global behaviors. These mechanisms are promising as they can represent a wide variety of situations. However, the model presented some limitations. While several contexts could influence an agent, a behavior could only result from a single context. More complex behaviors may result from a combination of contexts. We present a new model based on the core principles of Soussi and Savelli's work. We introduce a new behavior architecture. We present a new way to define groups within the model with task distribution. As a secondary objective, we aim to ensure the model will be suitable for use in a serious game for training decision-makers in emergency crises.

2 AGENTS

Following the context-based model, agents cannot act without the influence of contexts. Their role is to process the influence and behaviors coming from the contexts. Each agent has character attributes representing their capacities (for instance, their personality and abilities). A character attribute has a name, a tendency, and a value in $[0, 100]$, as described in [12]. A tendency is a value the attribute takes when no context influences it. Character attributes ensure that several agents submitted to the same contexts will not all adopt the same behaviors.

Contexts can influence the value of agent character attributes (but not the tendency). For instance, a context surrounding a music

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speaker could increase an agent's excitement if said agent is under the context's influence.

In COBAI, we added a workspace, a memory space where the agent processes contexts and behaviors.

3 CONTEXTS

In the context-based model, entities called contexts handle all agent interactions with their environment (including other agents). They serve a mediating purpose between the environment and the agents. Thus, any useful information for the agents (non-exhaustively: obstacles, events, other agents, objects) is associated with a context with appropriate behaviors.

A context has a force in $[0, 100]$. Agents will prioritize behaviors coming from contexts with the highest force. The force will also weigh the influence of the context on the agents' character attributes.

A context can be localized or non-localized. A localized context has a position in space and an influence zone representing the points in space where agents are submitted to it. It can be associated with an agent, thus following its location. A non-localized context contains a dynamic list of agents submitted to it.

In COBAI, a context's force can be a mathematical function depending on character attributes or distance from the context's source (if localized).

4 BEHAVIORS

In the context-based model, a behavior is any action an agent performs in the simulation, visible to the user (graphical animation) or not (modification of simulation data). The main contribution of COBAI is a new way of handling those behaviors.

Any behavior in the simulation is part of a behavior rule consisting of premises (as in a logical rule), a behavior with modalities, and an associated context. A modality is any element (data, script) necessary for the behavior execution. For example, a behavior *Move* requires a script, a position, and a speed. For a behavior to be executed, each modality needs to have an instance, an agent must be under the associated context's influence, and the premises must be valid for this agent. A behavior rule in which some modalities do not have an instance is an incomplete behavior rule. We use the following formalism to represent behavior rules:

$[premises]BehaviorName(modalities)\{BehaviorVariation()\}$

In the simplest case, a context contains a complete behavior rule. According to its character attributes, an agent submitted to this context has every modality to execute the corresponding behavior. A simple example of this situation is a non-localized context containing the following behavior rule: $[]Move(location = home)\{Walk()\}$, where *home* is a variable containing the location of the agent's home. An agent submitted only to this context will walk home. However, several contexts can contain incomplete behavior rules referring to the same behavior. An agent must be submitted to several complementary contexts to execute the behavior. The incomplete behavior rules will be combined in the agent workspace to form a single complete behavior rule.

Non-localized contexts can represent resources, the means available to an agent (for example, arms and legs) to act, similar to Lamarche et al. [3]. The use of resources partially solves compatibility between behaviors. A context representing a resource contains incomplete behavior rules requiring this resource, with the corresponding script but missing other modalities. When the agent executes a behavior B using a resource R, R is mobilized, preventing other behaviors requiring R from executing. When B is interrupted, R is released, other behaviors can use it. Let us consider the previous example of an agent walking home. Instead of encountering a single context bearing the behavior with the script to walk and the destination, the agent would have a resource *Legs* with an incomplete behavior rule $[]Move(destination)\{Walk()\}$. Upon encountering a context with a matching behavior rule $[]Move(destination = home)\{\}$, the agent will combine the two behavior rules to obtain a complete behavior rule $[]Move(destination = home)\{Walk()\}$. Now let us consider agents have a character attribute *Sporty*. In their resource *Legs*, they could have two incomplete behavior rules: $[Sporty < 80]Move(destination)\{Walk()\}$ and $[Sporty >= 80]$ $Move(destination)\{Run()\}$. With the added premises, agents will adopt a different version of the behavior *Move* depending on their *Sporty* value when encountering the complementary context bearing the incomplete matching behavior rule $[]Move(destination = home)\{\}$. Some will run, and others will walk home.

A tool, a specific type of resource, represents an object (for instance, a phone) an agent can use to execute a behavior (for example, phone someone). Unlike resources, a tool requires using other resources (in the previous example, an arm to use the phone).

This new behavior architecture allows the representation of more complex situations found in real life. An agent can execute several behaviors provided they are compatible (using different resources). Behaviors can result from indirect interaction between contexts instead of only one context.

5 GROUPS

The context-based model does not allow cooperation between agents. In COBAI, we propose a definition of groups and cooperation using the new behavior architecture.

A single context can represent a circumstantial non-organized group where all agents execute the same behavior. The context then bears the required behaviors relevant to the situation. However, a group needs to be more explicit when representing a conceptual structure like a team, an organized group (for instance, an army), or when it is more natural to give behaviors at a collective level than individual agents.

These explicit groups are represented by an agent and an associated non-localized context (a group agent and a group context). The group agent allows the group to be influenced by contexts and process behaviors to distribute tasks to agents gathered by the group context. Every agent in the group is submitted to the group context. This mechanism allows the group to provide behaviors to its members.

6 FUTURE WORK

We are now working on a methodology for application design with COBAI. We will describe the design process and represent classic situations. We also aim to test further the capacities and limitations of the model on the conceptual level (which situations can or cannot be represented by COBAI) and technical level (performances when using a large number of agents in our Unity simulation).

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