Mind Maps as Behavior Controllers for Virtual Characters

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Abstract
We propose a new *mind map interface* method for controlling virtual character's artificial intelligence and behavior in games. Commonly used techniques, such as scripting, require an extensive analysis and discrimination of all the possible behaviors that are triggered by the stimuli received by the virtual character. Scripting is also subject to strict syntax rules that may be hard to comprehend by non-expert users. Instead, our method can be easily created by users that do not have any technical background, since they graphically represent the natural process of organizing information in the human brain.

Our mind map interface method follows a behavior-based architecture combined with an emotional depth module to control the character's behaviors individually in a game. We implemented a graph-based visual editor to ease the definition of the mind map nodes interactively. We also show how mind maps were implemented in the LIFEisGAME (LearnIng of Facial Expressions usIng Serious GAMEs) project as a proof of concept.

Keywords
Mind map, behavior, virtual characters, social simulation, autism spectrum disorders

ACM Classification Keywords
H.5.2 [**Information interfaces and presentation (e.g., HCI)**]: User Interfaces.

General Terms
Algorithms, Human Factors

Introduction
Creating behaviors for virtual characters is usually a laborious and time-consuming task because it involves specifying rules for every possible stimuli. We implemented a novel method of defining virtual character's behaviors through mind maps for social simulation in games. Our mind is programmed to reproduce a behavior based on the ramifications of a central concept, such as defined by a concept map or a mind map [2]. A mind map consists in a diagram used to represent related contents that derive from a central idea [4]. Since this method resembles the way our own mind works, it is both intuitive to use and different from person to person. As stated by Eppler [6], mind maps are a preferable way to express one's way of thinking when compared with other diagram methods like concept mapping, visual paradigm, UML, etc. It has also been shown that the use of mind maps is a way to improve teaching, detailing and recognizing of complex concepts [13]. Therefore, we present a method that allows the user to specify the behavior of a synthetic agent in a virtual social world through our mind map interface.

Social interaction is heavily based on expressing and recognizing emotions. This process is continuously evolving during interaction and is modified according to the personality of the individuals, background context, social values, norms and customs, and the opinion of each individual towards the other. Thus, facial expressions play a crucial role in the communication process as a privileged means to convey emotional information [10]. However, the creation of a rich virtual social environment is not straight-forward. It involves complex concepts related to character's behavior that, if misused, may easily compromise the realism and the player's immersion [3]. Several architectures have appeared with the goal of modelling the emotional behavior that results from different situations [7, 8, 3]. In these architectures, characters have a set of behaviors that are chosen based mainly on the emotional state and the stimulus. The concept of behavior, as presented in Mataric et. al. [11], can be augmented from two other concepts: the six basic emotions, as defined in Ekman et. al. [5], and the actions that can be performed by the agent, e.g. "Smile" or "Slap". Our work was inspired by Roesch et. al. [12] because it defines a set of five recommendations for modelling emotional state machines.

Nowadays, the behavior of a virtual character is commonly defined by using a set of encoded scripts, such as Lua or Squirrel. This code is compiled or interpreted by a script engine and used within a game. This process may be slow, particularly when some conditions or variables of the characters must be evaluated in real time against the script rules. On the other hand, the process of scripting is slow and has to follow strict notation rules. By using scripts, all the details have to be thoroughly specified, which gives the user more control over the character. Nevertheless, this leads to an undesirable amount of work, where all the outputs for every stimulus have to be predicted. Each scripting language has its own syntax, although they all roughly consist of a set of pre-conditions and rules.

Our technique for specifying character's actions through

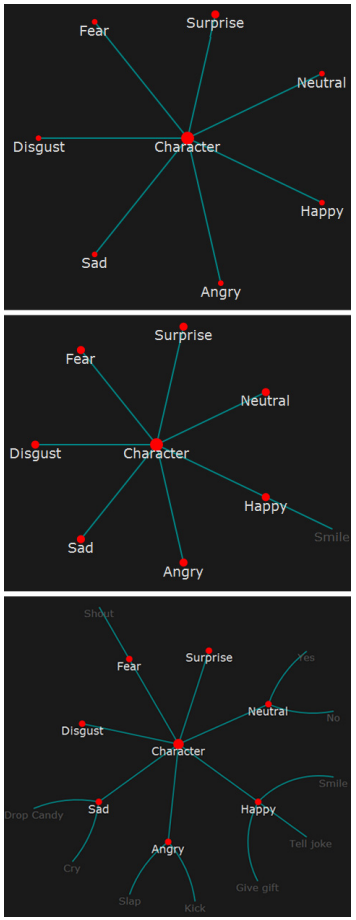

Figure 1: Mind map overview. Top: The initial mind map composed by the root node (character) and the emotion nodes; Middle: Mind map after adding the "Smile" action to the "Happy" node; Bottom: An example of a mind map after adding several actions.

mind maps has almost the same advantages as scripting. Like the scripts, it is made in an offline step of the game configuration and is not evaluated in runtime, also allowing the definition of the possible interactions a character can receive and/or perform. Mind maps do not allow as much control over the character's behavior as scripts because outputs are not directly linked to input by rules. However, it is easier to modify the behavior of the characters in a game just by changing their mind map's parameters, whereas with scripts it is necessary to change the rules. With mind maps a character may also automatically choose the response to an action even if that action was not initially presented in its behavior. This is done by learning the emotion associated with that action from the other character's mind map.

This method was implemented in the LIFEisGAME project [1], composed by four game modes, where each mode addresses the learning stages defined by Kolb [9]. The mind map method was implemented as a core component of one of the game modes, called "Live the Story". This mode presents the players typical daily life situations to improve the acquired communication skills knowledge from the virtual world to the real life. The player must interact with the characters to achieve a goal, related to emotion recognition. The mind-mapping method provides LIFEisGAME's users (therapists and/or parents) a new way of specifying the behavior, emotion, actions and personality of characters in the game.

The Mind Maps Method

Creating and deploying behaviors of virtual characters through scripting easily becomes impractical when the number of conditions increases. We defined a novel method that can create simple and complex behaviors based on the use of a mind map interface. The social component of the virtual characters is defined by a behavior model, which includes a mind map, personality and mood properties. Our pipeline involves three stages: creating the mind map; defining the character's personality and mood parameters; associating the behavior model to the virtual character.

Creating the mind map

It starts with a base mind map that includes a root node (containing the character's name) connected to seven nodes, one node per emotion and one node for the neutral stance (see Fig. 1). Even though the method is generic, our description focuses on the six basic emotions defined by Ekman et. al. [5] for simplicity. A node can be an emotion or an action. An action is something performed or received by a character that is either driven by an emotion or as a response to another action. Consequently, actions are represented in the mind map as leafs of the emotion nodes ramification. Fig. 1 illustrates the process of a user creating a mind map by adding actions to emotions.

Each action has a set of parameters: name; weight that indicates how much it affects its parent emotion; and two boolean flags, used to indicate if the action can be received and/or performed by the character. Actions are created by the user through a visual editor by choosing the parent emotion, to which the action should be added. Since each character has its own mind map, there might be actions that are present in a character and not in the other. Thus, it may lead to a situation where a character receives an action and does not know how to respond. In this case it will learn from its interlocutor's mind map the emotional state of the action and add it to its own mind map.

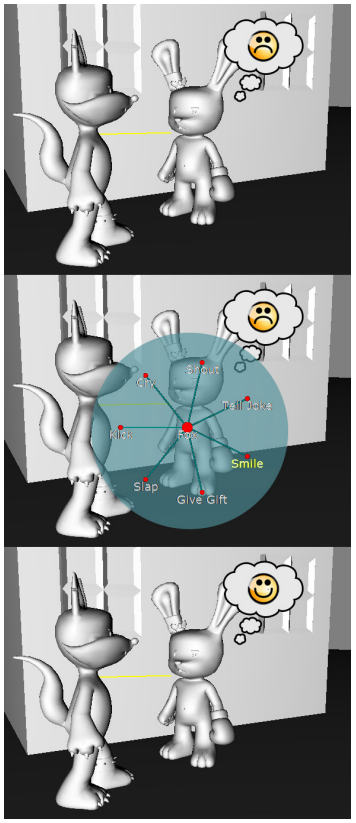

Figure 2: Social interaction simulator after applying different mind maps. Top: Rabbit character is sad. Middle: Fox character, controlled by player, uses the "Smile" action. Bottom: Rabbit character becomes happy.

Defining the character's personality and mood
Mood is a special entity inside the behavior model, since it represents the current emotional state of the character. This represents how the character feels in a certain moment without considering the intervention of any special object, character or situation. This resembles how we feel when we wake up before anything happens; on some days we wake up angry, while on other days we wake up happy.

However, the tendency for having a certain mood depends heavily on the *personality*, which is an important aspect to consider when defining a mood. We defined the personality as a probability between the following state variables: angry, sad, happy, surprise, fear, disgust and neutral. The personality represents a tendency of being in one or more of these states. Each of these state variables will have a value between 0 and 1 (or 100%) and the sum of the values for all variables must be 1 (or 100%). The mood will also converge, to some extent, to the personality after a predefined period of time without any interactions from other characters. Mood follows the same structure as personality. Personality is a constant that affects the way characters react when an action is performed upon them. It is important to notice that the mood of a character will be evolving throughout the story while the personality remains constant.

Another key factor that affects the behavior of a character besides mood and personality is the *background context*. The background context is a situation surrounding an event, which affects the emotional state of the virtual character. Thus, it can be defined in the same way as personality and mood.

Last, we define the *affection matrix*, which consists on a set of values that holds the specific mood of the virtual character towards every other character. The affection matrix dynamically changes the impact weight of an interaction based on the history of the relationship.

Associating the mind map to the virtual character
The association of a mind map to a virtual character is an automatic process. It consists on exporting a XML file of the mind map interface, which is imported to the game. The game dynamically creates a new character for each XML file automatically associated with the mind map. Each XML file contains the mind map definition, personality, mood, background context influence and the affection matrix.

Implementation

We created an offline configuration tool that we call mind map interface and a game mode prototype embedded in the LIFEisGAME project called "Live the Story", which uses the output (a mind map) of the configuration tool. The mind map interface was implemented using HTML and Javascript (jQuery and JIT). The LIFEisGAME's "Live the Story" game mode was implemented using C++, QT and OpenGL 3.0. When the game loads, each character is initialized with its own mind map and behavior. Thus, the characters automatically know which actions can be performed and how to react when other character's actions are performed upon them. The system will recognize the actions and its associated properties and adjust dynamically to them, as seen in Figure 2:

The player controls its own avatar and is able to interact with the non-playable characters. When an interaction occurs the system predicts the outcome on both characters by using the mind maps, mood, personality, background influence and affection matrix of each of the characters. All calculations are transparent both to the

user who created the mind maps and the player, even though the first has complete control over all of the variables that were used to create the simulation. When used within "Live the Story", the mind map interface allows the therapist to quickly specify new behaviors and actions for the characters. These behaviors are automatically updated within the game and the therapist can dynamically establish new objectives that the player must achieve, which will contribute to a more efficient therapy session.

Discussion and Conclusion

The challenge is to allow non-expert users, with no programming background, to easily create coherent character behaviors for games. We have shown how mind maps can be used as an innovative and intuitive method of specifying the behavior and possible actions of characters. Since the character's behavior is now based on emotions instead of rules, the characters can dynamically respond to actions that were not initially specified in their mind maps. Due to its dynamism, mind maps can also be used as a general mechanism for developing artificial intelligence in games. One limitation of this method is the impossibility to define precisely the result of an action, since it will be calculated by weighting all the behavior parameters. This may be solved by allowing the user to define what should be the output of a certain action and the conditions in which it should happen. As future work, we expect to test this method, implemented in the "Live the Story" game mode, within the community of children with Autism Spectrum Disorders (ASDs). These tests will focus on the usefulness of both the mind map interface for the therapists and the effects of the character's social behaviors on the children.

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