Towards Interactive Cognitive Agents with Culturally Restricted Behaviors

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Abstract: Culture is one of the most important factors that influence human interaction. Evidence shows that people's culture determines the type of actions they are able to perform in certain situations. Consequently, in the field of HCI, the study of culture has become essential for the design of interactive cognitive agents embedded in social and realistic virtual environments. However, current attempts to enculturate such agents focus on modeling specific aspects of culture, leaving aside the implementation of more integrative and biologically inspired models. In this paper, we propose an integrative framework as a novel approach to the modeling of culture in cognitive agents for HCI applications. This integrative framework is designed to serve as the underlying architecture of interactive cognitive agents whose behavior is influenced by specific cultural backgrounds. The architectural design and operations of such integrative framework is based theories and models formulated in psychology and neuroscience.

1 INTRODUCTION

People belonging to different societies perceive and respond to particular events in contrasting ways. The cultural differences among societies and the increasing facility of people to communicate and move around the world makes cultural conflicts and misunderstandings an everyday issue. Related literature shows how diverse disciplines address many of these types of conflicts from different perspectives, trying to develop models and strategies to minimize the impact of cultural differences on the interactions between humans or between humans and machines.

Conflicts caused by cultural differences highlight the importance of understanding culture (Lee and Nass, 1998). Certainly, this would enable the design of environments for human-human and human-machine interactions that reduce the impacts of cultural differences on intercultural virtual and physical encounters. In this line, some observable causes can be identified, including the ambiguity in understanding verbal and non-verbal expressions of people from different societies, the differences in their attitudes toward same things, the variability in the intensity and type of emotions they express when experimenting determined events, and the diversity in the type of actions they perform as reactions to same situations.

Culture related issues can be addressed in various ways. For example, interactive cognitive agents whose behavior is restricted by a cultural background may be useful in diverse multicultural scenarios. Cultural Cognitive Agents (CCAs) are autonomous agents whose underlying architecture includes a number of components embodying cognitive and affective capabilities, which enable the emergence of culture-driven behaviors. In the case of the problematic interactions between students and tutors with different cultural background, CCAs might play the role of a virtual tutor that embodies certain culture traits according to the culture of students, allowing thus a more convenient and conducive environment for learning.

Research focused on the analysis and measurement of how important is for an intelligent system to recognize the user's culture and behave accordingly has shown that CCAs may significantly improve the performance of HCI systems. For example, CCAs may be able to respond to humans as they expect, given that the agent is aware of the traditions, beliefs, and other aspects inherent to the user's cultural background (Payr and Trappl, 2004). Furthermore, such research has led to the creation of a number of models for enculturating agents (Rehm et al., 2007), which are usually focused on the simulation of specific aspects of culture and are supported by the results of

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empirical observations and social-psychological theories (Rehm et al., 2007). However, a general and more integrative model of culture for cognitive agents based on biological findings has not been addressed. In this paper, we discuss theoretical and computational models of culture in order to identify key aspects to be included in the underlying architecture of interactive cognitive agents whose behavior is culturally restricted. We present an integrative cognitive framework designed to include components that model the various identified aspects of culture as well as other cognitive and affective mechanisms associated with the culture construct.

2 RELATED WORK

We review some of the most influential theories in the development of computational models of culture.

2.1 Theoretical Models

The development of computational models of culture has been mainly inspired by theoretical findings originated in areas such as social sciences and psychology. One of the most influential theories is the dimensional model of Hofstede (Hofstede, 1991). This is a social model developed on the basis of data from a survey conducted among employees at IBM and students from 23 countries. The main hypothesis of Hofstede's theory is that people's culture can be represented as a point in a five-dimensional space:

1. *Power distance*: level of people's acceptance in the distribution of power among members of organizations, whether equitable or inequitable.
2. *Individualism-collectivism*: degree to which people act as members of a group or as individuals seeking personal achievement.
3. *Masculinity-femininity*: emphasizes on gender equity, and women's and men's values.
4. *Uncertainty avoidance index*: level of tolerance of people to face uncertainty and thus change or not their way of living.
5. *Long-term Orientation versus short-term Orientation*: degree to which people are interested in the future, in the present and the past.

Other computational models of culture have also been developed on the basis of the cultural schema theory (Nishida, 1999). This is a cognitive-based approach that tries to explain how culture is learned and represented in the human's brain. This theory characterizes culture as an organized and structured network of knowledge or schemas, which are supposed to be retrieved in cultural situations in order to provide a person with the appropriate knowledge to understand the current scene, create expectations, and respond accordingly (Nishida, 1999).

2.2 Computational Models

A variety of computational models have been proposed to develop Autonomous Agents (AAs) whose behavior reflects certain cultural traits. For example, Jan et al. (Jan et al., 2007) propose a model for developing conversational AAs that incorporate a specific cultural background. This proposal focuses on the modeling of cultural differences in proxemics, gaze, and overlap in turn taking in North American, Mexican, and Arabic cultures. Jan et al. use data derived from empirical observations reported in related literature to assign proper values to each these three aspects in conversational agents embodying a determined culture. In the underlying architecture of these agents, proxemics is represented by the beliefs of the agent's relationship with other agents, gaze is modeled using a probabilistic schema that allows moving between five predefined gaze states, and overlaps in turn taking is implemented by using a gaussian distribution in which mean and variation reflect cultural traits.

Rehm et al. (Rehm et al., 2007) propose a computational model of culture based on Hofstede dimensions. In this model the recognition of user's cultural background is used to adjust the behavior of AAs. Agents interact with users by embodying their same cultural background, which is matched to one of the following prototypes: Arab, Chinese, Germanic, Israeli, Japanese, Swedish, Thai, and North American. Five steps are implemented to achieve such procedure. *Behavior observation*: a Wii remote controller is used to collect user's non-verbal information by sensing their movements in a 3D space. *Appraisal*: the data collected from users (spatial extent, speed and power factors) are analyzed to match one of the eight culture prototypes. *Mode*: the user's culture is linked to the agent's culture; in this case, the agent adopts the same culture of the user. *Simulation*: the agent's non-verbal behaviors such as sound, spatial extension, speed, and power are calculated according to the designated culture. *Behavior display*: the agent displays accurate culture-driven behaviors. In a more recent publication, Rehm et al. (Rehm et al., 2009) describe a similar model of culture in which the behaviors developed by AAs imitate the actions of German and Japanese individuals identified in video clips recorded by the authors. Three scenarios were established for such videos: meeting someone for the first time, negotiations, and interactions with people with a higher social status.

A computational model of culture based on the schema theory and the appraisal theory of emotions (which explains the elicitation and differentiation of emotions on the basis of the relationship between individuals and their environment) is proposed by Taylor and Sims (Taylor and Sims, 2009), which aims to develop interactive 3D cultural characters for cross-cultural training. The authors propose a general framework called the *Cultural Cogntive Architecture*, which makes use of particular schemas of knowledge to elicit culture-driven behaviors. In this model, cultural schemas contain data that is used for the establishment of adequate sequences of behaviors that cultural characteres must develop or expect in determined situations. Moreover, appraisal processes provide mechanisms for assessing cultural events under certain appraisal dimensions, such as *goal conduciveness* and *compatibility with internal and external standards*. This process is restricted by cultural schemas leading to emotional data useful for generating coherent agent's behaviors.

In summary, most of the current attempts to model culture traits in AAs focus on the generation of certain cultural behaviors, leaving aside the creation of more general models which allow AAs to implement any behavior on the basis of their cultural background. For example, the model proposed by Jan et al. (Jan et al., 2007) focuses on modeling proxemics, gaze, and overlap in turn taking, neglecting aspects such as the utility of goals an emotions. Furthermore, such proposals are not concerned with developing models of culture that allow the integration of new cultural behaviors or cultural traits in AAs.

3 CHARACTERIZING CULTURE

The word culture may refer to very different features depending on the context, ranging from superficial manifestations such as clothes and language, to deeper mental models influencing human aspects such as socialization and needs (Hofstede, 1991). However, what do all these features have in common?, which are the main features of culture? This section discusses the common features of culture.

Culture is acquired. People learn cultural values by interacting with other individuals and the environment. Tylor (Tylor, 1874) states that culture is a complex whole including capabilities and habits acquired by an individual as a member of a society. Keesing (Keesing, 1974), Vatrapu and Suthers (Vatrapu and Suthers, 2007) and ScHall (Schall, 2010) prioritize the influence of the context in culture. Hofstede (Hofstede, 1991) defines culture as a collective programming of the mind that distinguishes the members of one group from another.

Culture is collective. Individuals belonging to the same groups share similar cultural values. Hofstede (Hofstede, 1991) affirms that each culture is constituted by groups such as those formed in family, school, religion, and work, which are considered as subcultures that influence the behavior of individuals in different ways. Vatrapu and Suthers (Vatrapu and Suthers, 2007) state that culture is shared knowledge, created by a group in order to rule the way in which people perceive, interpret, and express the reality around them. Straub et al. (Straub et al., 2002) state that culture is shared by individuals which share the same space and engage in similar activities.

Culture is subjective. The perception of an individual about the context depends on his own cultural values. Researchers studying culture issues assert that the ideas and conceptions of people are true only so far as their civilization goes (Kitayama and Cohen, 2010). Sumner (Sumner, 2013) developed the term ethnocentrism, which states that the individual's own culture is particularly important, and that other cultures are measured in relation to the one's own. Herskovits (Herskovits, 1972) affirms that judgments are based on experience, which is strongly influenced by the culture of individuals.

Culture is dynamic. Culture evolves over time in order to adapt to external influences. According to Keesing (Keesing, 1974), the technological development and economic, politic, and social changes play a main role in culture evolution. Hofstede (Hofstede, 1991) and ScHall (Schall, 2010) affirm that when members from different cultures meet and interact, they are mutually influenced, producing changes in their respective cultures. In addition, Scherer and Brosch (Scherer and Brosch, 2009) consider that own beliefs and thoughts change over time, producing an evolution in culture. Hofstede (Hofstede, 1991) states that culture is changeable as members of groups are exposed to external influences.

Culture influences behaviors, emotions, and cognition. Many studies about culture are based on observable behaviors of individuals. Hofstede (Hofstede, 1991) describes culture in terms of five cultural dimensions, each of them explained in terms of attachment to stereotypical behaviors. Trompenaars (Trompenaars and Hampden-Turner, 1998) studies culture in terms of the way in which people solve problems. Hall (Hall, 1966) investigates the influence of culture in physical distances and gazes while people communicate. ScHall (Schall, 2010) identifies cultural differences as the main influence in the way in which people obtain, interpret, and share information. Regarding emotions, several studies state that culture represents a high influence in the way in which people manage and express emotions; Trompenaars (Trompenaars and Hampden-Turner, 1998) identifies certain patterns of behavior defining whether expressing emotions is acceptable or not in a given culture.

Culture is personal and unique. Despite of considering culture as a collective phenomenon, there are personal traits that produce variations in the cultural background of individuals in a same culture. Hofstede (Hofstede, 1991) recognizes the mutual influence of personality and culture, which produces unique cultural configurations in each individual. According to Hall (Hall, 1966), each individual develops his main culture, maintaining a continuous process to adapt it according to the contexts in which he is involved in the course of his life.

4 MODELING CULTURE IN CCAs

In the previous section we identified some key characteristics of culture. The identified set of features shows that a synthetic model of culture may become as complex as needed, and that there will always exist a trade-off between complexity and realism. We propose interactive cognitive agents as a good approximation for facing such trade-off. In this section we briefly discuss some cognitive capabilities needed in CCAs in order to illustrate the complexity of modeling culture. We then introduce a cognitive integrative framework that aims to serve as the underlying architecture of CCAs, which provides a favorable environment for modeling the different aspects of culture.

4.1 Cognitive Capabilities for CCAs

Cognitive architectures of AAs are regarded as integrative frameworks aimed at unifying a number of heterogeneous components whose interaction produce cognitive behavior. Often, these components represent computational models of cognition and emotion and implement mechanisms to reproduce the behavior of processes such as perception, reasoning, and decision making. The main assumption is that from the joint operation of this type of process will stem believable and intelligent behavior in cognitive agents, which are software components that proactively act in order to reach some objectives, based on knowledge, skills, and the information retrieved from the context. In order to show such kind of behavior, cognitive agents have the following capabilities:

- Autonomous execution and proactive behavior. Agents have knowledge about their goals and automatically perform actions for achieving them.
- Representation and storage of knowledge. Agents can maintain a repository of structured knowledge (e.g., using an ontology, trees and rules).
- Reasoning capabilities. Agents implement inference mechanisms to produce new knowledge by reasoning over their knowledge base.
- Perception of the environment. Agents perceive information of the context in order to update their knowledge and therefore adapt their behavior.
- Learning from experience. Agents evaluate the results of performing certain actions under certain situations. They are able to adapt their actions in order to improve their performance.
- Communication and cooperation with other agents. Agents are able to communicate in order to coordinate their activities and achieve global goals.

The main reason of proposing cognitive agents as the underlying technology for developing a synthetic model of culture is that they present many capabilities which simulate to some extent the cognitive capabilities of human beings. As discussed in Section 3, culture involves a series of aspects that CCAs must model in order to capture the complexity of cultural behaviors. The acquisition of a cultural configuration by the agent requires the capacity for representation and storage of Knowledge. Knowledge bases are a convenient approach for such requirement given that they are attached to structures like ontologies and desicion trees which allow computations and inferences. For example, ontologies are suitable for representing models such as those proposed by Hofstede (Hofstede, 1991), Hall (Hall, 1966), and Trompenaars (Trompenaars and Hampden-Turner, 1998), which consist of a set of independent variables that describe cultural preferences in people. In order to model such acquisition process, CCAs require to take information from the environment and construct a cultural configuration from such information. Two main capabilities are involved: communication and perception. While the former allows the agent to capture information about cultural configurations of other agents and compute an influence over its own cultural configurations, the latter enables the agent to take information from symbols in the environment.

CCAs must be assigned a specific cultural configuration, which is stored in their knowledge bases. The structure of such the knowledge bases depends on the needs of the application. For example, if the applica-

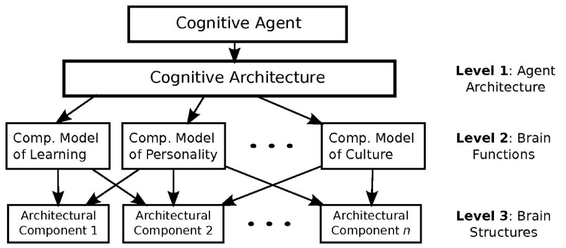

Figure 1: Integrative approach for modeling culture in cognitive agents.

tion is based on the model of Hofstede, such configuration can be represented as a set of values representing the cultural dimension of the model. Furthermore, CCAs must be able to tune their culture by perceiving their environment and learning from the actions of humans and other agents. For example, a CCA whose objective is to model the culture of a user could obtain an initial cultural configuration based on the demographical information of the user (e.g., its nationality, age, and sex) and personalize such configuration as the agent learns from the actions of the user.

A CCA must embody cognitive processes to be able to combine and make operations over different cultural configurations in order to represent the mixing of cultures of different groups. Given that cultural configurations are stored in knowledge bases, mixing operations are performed by reasoning and making inferences over such knowledge. For example, consider an application aimed at supporting collaboration of users with the same nationality. It is agreed that culture of individuals with the same nationality may be quite diverse depending on their age, sex, social position, and interests. In such case, cultural configurations of different CCAs, would be based on the same initial cultural configuration (i.e. the national culture) and each of them will be adapted by computing the impact of different groups to which the user belongs. In applications involving several CCAs, each of them must maintain a knowledge base of his own cultural configuration, but also an own perception of the cultural configuration of other CCAs.

4.2 Cognitive Architecture for CCAs

The analysis in the previous section reveals that culture is a human phenomenon that results from the operation of several cognitive processes. In this line, a computational model of culture must implement several mechanisms associated to various cognitive and affective processes as well as psychological constructs. We present an *integrative cognitive framework* that aims to provide a favorable environment for the unification of several computational models implementing diverse cognitive and affective processes associated to culture, such as decision making, learning, and personality (see Figure 1).

As Figure 1 shows, this integrative framework represents the underlying architecture of the CCA (level 1 in figure), which enables the emergence of culturally restricted behaviors. The architectural design and operational assumptions of such agent architecture are based on concepts, theories, and models formulated in disciplines devoted to investigate human behavior and its relation to the information processing in the brain, such as psychology and neuroscience. On the one hand, psychology offers high-level explanations of the brain processes underlying human behavior (including cultural behavior), enabling the understanding of their main functions, their working assumptions, and their interactions with other brain processes. On the other hand, neuroscience provides theories and models that investigate the cognitive and affective processes involved in culture in terms of brain functions, brain structures, and neural pathways, which is useful to understand in more detail the internal procedures necessary for the modeling of cultural behavior.

As explained above, culture is a complex phenomenon that is subject of study in various disciplines. This psychological construct is being addressed at different levels of abstraction and from different perspectives. As a result, several theories and models explaining culture in individuals and groups have been formulated. Hence, in order to keep up with such advances and develop a computational model of culture able to capture new evidence, the cognitive architecture of a CCA should meet the following two requirements:

1. *Integrative and scalable architecture*: CCAs have to be designed so that they incorporate frameworks that consistently unify theories and models that explain diverse aspects of culture, and other cognitive and affective aspects as well. Additionally, such architectures should provide suitable environments for the steadily incorporation of new findings about this human phenomenon.
2. *Consistent model for the interaction of various cognitive and affective processes*: since cultural behaviors are the result of the operation of a series of cognitive processes, computational models of culture must embody proper interfaces for the interaction of the affective and cognitive functions underlying culture.

The framework introduced above is based on evidence from psychology and neuroscience, which simplifies the achievement of these two requirements. As shown in Figure 1, our proposed framework includes a series of computational models of cognitive and affective processes that represent psychological constructs or *brain functions* (level 2 in Figure), such as personality, learning, and culture. The interaction between these components enables the dynamics of cultural behaviors in CCAs. Furthermore, they represent abstract models whose behavior emerges from the operation of a number of architectural components (level 3 in Figure), which simulate the functionality and architecture of *brain structures*.

In this manner, such proposed cognitive framework allows us to implement an integrative and scalable computational model of culture, since any available or new neuroscientific theory addressing some brain function or psychological construct can be implemented by using the structural and operational basis within the agent architecture. Similarly, this framework meets the second requirement since computational models of cognitive and affective functions are implemented using the same or compatible structural and operational machinery used to implement the model of culture.

5 CONCLUDING REMARKS

In this paper we identified key characteristics to be modeled in interactive cognitive agents aimed at addressing the complex requirements of contemporary applications in HCI. We presented an integrative framework as the underlying architecture of such interactive cognitive agents that attempts to integrate the various components of culture. Considering that the current state of knowledge of most aspects related to culture in individuals is still limited, but in development, this integrative approach becomes convenient for the computational modeling of culture. Additionally, neuroscience offers theoretical models of the processes that underlie human behavior and which are common to all individuals, allowing the modeling of the process of culture in autonomous agents through the implementation of the basic mechanisms from which all kind of cultural behaviors emerge. Thus, instead of dealing with the question of why and how culture is different among people and societies, we focus on the synthesis of the brain mechanisms that underlie the development of cultural aspects in humans.

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