

Breakthroughs and Challenges in Culturally-Aware Technology Enhanced Learning

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Abstract. *This paper aims to shed light on the major developments in culturally-aware technology enhanced learning (culTEL) based on the work conducted over the past five years in the field. Highlights of the breakthroughs that been achieved are presented alongside with a review of the main problems and challenges that require deeper investigation. The paper discusses the significance of these developments and concerns along with potential areas of study essential for the advancement of culTEL research.*

Keywords: Breakthroughs, challenges, review, research directions, culturally-aware technology enhanced learning

1. Introduction

Largely considered as lacking a generalized representation, culture has been traditionally branded as an ill-defined domain [1]. This view is motivated by the complex nature of culture which is shaped by different interpretations from individual and group perspectives. In other words, concrete manifestations of abstract concepts are perceived as cultural phenomena when recognized through specific traits, characteristics, behaviour, preferences or even beliefs typically associated with a particular cultural group. For technology enhanced learning (TEL) this meant that design features, whether deliberate or unintentional, stimulate positive and/or negative reactions in users because of their cultural perceptions. The risk of alienating or not appealing to users drove the need for cultural awareness in TEL which led to having to deal with the intangible and oftentimes intractable nature of culture, and inspired the migration towards computationally-motivated methodologies.

Several important developments have taken place in the field of culturally-aware technology enhanced learning (culTEL) environments within the past five years. The landscape of culture as an ill-defined domain has been steadily changing from unfocused, anecdotal approaches towards the use of computationally-viable models and techniques. Small pockets of works have emerged in the field as proposals for cultural models have increased ranging from interface guidelines to adaptive mechanisms to data representation standards. Though far from consensus, the situation in culTEL is greatly improved and this paper seeks to shed light on the current state of the art in

order to understand what has been achieved and what remains to be done. The paper is organized as follows. Section 2 highlights major developments and breakthroughs in culTEL research specifically in acquisition-oriented and adaptation-oriented environments. Section 3 reviews the critical challenges that require deeper investigation and open issues that remain to be addressed. Section 4 discusses the significance of these developments and concerns, and identifies potential areas of study that are essential for the advancement of culTEL research. The paper concludes in Section 5 with implications and possibilities for the future of culTEL environments.

2. Important Developments

Ranging from abstract conceptualisations to concrete implementations, major developments and breakthroughs have occurred in culTEL research. Categorized into three main areas, this section reviews some of these significant and recent advancements.

2.1 Recognition of the Need for Cultural-Awareness

Recognition of the need for and the lack of culturally-aware design in TEL have been among the most important changes taking place in educational research. In 2008, the first workshop on culturally-aware tutoring systems was held in Montreal, Canada followed by two successive workshops in the U.S.A. and United Kingdom [2]. Since that time, calls for computational approaches were made in the literature [1, 3, 4] and the importance of cultural design was made clear from instructional perspectives [5, 6] and from HCI perspectives [7]. More recently, studies were conducted that revealed a clear bias towards Westernised approaches [8] in publishing standards and also a lack of any cultural awareness in many educational environments developed by the Brazilian HCI community [7]. Furthermore, there is an upward growth in the number of cultural workshops and streams at major technical conferences in 2013 and 2014 such as EC-TEL¹, AIED², FLAIRS³, and the ACM Symposium on Applied Computing⁴. The formation of a special interest group in culturally aware technologies⁵ in 2013 cements this recognition and can potentially coalesce all of these disjointed threads of work into one focused goal-oriented unit. The mere fact that these studies are being conducted and the number of technical forums and workshops are increasing signal a change in the mentality towards culTEL design.

2.2 Computational Models of Culture

As mentioned earlier, there are numerous examples of theoretical cultural models in the literature as surveyed in [9]. Although not explicitly designed for TEL, extracts of

¹ <http://www.ec-tel.eu/>

² <https://sites.google.com/a/iis.memphis.edu/aied-2013-conference/>

³ <http://www.flairs-27.info/>

⁴ <http://www.acm.org/conferences/sac/sac2014>

⁵ <https://www.facebook.com/SIGoCAT>

the commonalities in these models are being used to build computationally-viable representations for culTEL environments. Ontologies have become the representation medium of choice because they can be used to define general knowledge concepts that relate to cultural descriptions of real-world phenomena and provide foundational semantic bridges between intermediate levels of cultural abstraction. The Upper Ontology of Culture (UOC) [1] is one of the first heavy weight upper-level ontologies intended to provide a backbone for structuring lower-level domain specific ontologies that describe an area of culture in more detail. An advanced version of the UOC has been developed. The MAUOC [10] defines core concepts such as cultural elements, behaviours and entities which are important for applications in culTEL and specifies formalisms for detailed conceptual representations of culture based on a survey of foundational cultural theories. Examples of cultural user modeling are found in [11] and [12]. General cultural user modeling was done in CUMO by Reinecke et al. [11] using Hofstede's dimensions whereas deeper modeling of individuals and their societal units was done in the CSM developed by Mohammed and Mohan [12] using country-level statistical data. Both efforts contribute towards greater understanding of the influences that impact upon users. Other examples of ontological learner modeling efforts include the cultural extension of the AdaptWeb project [13], the CAE-L ontology for identifying learner tendencies towards cultural preferences [14] and the MultiCultural Aspects Ontology used in the EduCA project for learning resource retrieval [15]. Lastly, conceptual models of intercultural communication [9] are coming to the forefront with important implications for culTEL environments that rely on non-verbal communication such as serious games and simulations.

2.3 Practical Systems

Culturally-aware TEL environments can be broadly categorized as either adaptation-oriented or acquisition-oriented [1, 16]. Both types of systems aim to interpret, model and use cultural backgrounds and influences of either individuals or social groups but for different purposes. Adaptation-oriented systems aim to change system appearance, behaviour and content to suit individual learners whereas acquisition-oriented systems aim to teach an individual about a particular social group or how to acquire skills for interacting with them. In both cases the use and generation of cultural contexts can be preset or manually loaded, partially automated or fully automated. Within adaptation-oriented culTEL systems, the localised Mathematics videos in [17], and the Computer Science programming game in [18] demonstrate how premade localised content can be used successfully to produce significant learning gains. The adaptive and intelligent systems described in [18, 19] along with the enculturated conversational agents (ECAs) in [20] provide examples of semi-automated and fully-automated approaches within the same grouping. Within acquisition-oriented culTEL, practical systems are commonly used for developing intercultural communication skills in the form of virtual learning environments and serious games such as in [21, 22] and also using ECAs such as in the CUBE-G project [4, 23].

3. Challenges and Open Issues

The models, systems and projects described in Section 2 provide evidence of the increasing maturity of the culTEL field and signal the move towards structured, scientific approaches for designing, implementing and assessing culturally-aware systems. Despite these developments, there are many challenges and open issues that require attention and some of these are discussed in this section.

3.1 Cultural Granularity

Many TEL projects use Hofstede's indices as a measurement of the cultural influences on students in order to adapt system appearance and behaviour, and select and modify educational content. This is a common starting point which has yielded positive results in some areas of research particularly those with enculturated agents. New challenges are being observed with country-level categorizations however such as the broadness of the scope and generic categories for typifying students who happen to have some interaction with a particular country. For example, mismatches have been documented with the expectations of student preferences based on Hofstede's values for a country and the actual preferences of the students from that country [14]. This means that the level of cultural granularity provided by broad cultural models not typically designed with computational applications in mind (see [9] for overview) may be too high to meet the requirements for culTEL environments. Finer-grained measurements sensitive to the subtle but critical differences across student cultural backgrounds caused by their differing degrees of membership to cultural groups are required for educational applications. Furthermore, the reliance on the values assigned at a country-wide or national-level can introduce potential flaws if the values were collected from small or biased samples. Related to this issue is the granularity of cultural data that can be collected from users. Studies have shown that various important pieces of information are required from users [12] but cannot be collected uniformly across countries [24]. The challenge of harnessing data from users is complicated since although data is available from many online sources such as social networks and national databases, the question of whether users are ready for their personal details to be used in culTEL environments remains to be answered.

3.2 Folk Approaches

One question that needs to be asked by anyone aiming to develop a culTEL environment is how to differentiate between folk approaches described in [10] and legitimate cultural conceptualisations identified in [25]. Folk approaches stem from subjective, personal descriptions and perceptions of cultural contexts which are used to represent cultural features in TEL. These introduce problems from conceptual and developmental standpoints. From a conceptual standpoint, folk approaches lack neutral abstractions that can be generalized and reused in different features of culTEL. This is a critical flaw because it works against the goal of 'coherent global views of the cultural domain' identified in [10] and prevents the interoperability and standardization of cultural representations. From a developmental standpoint, folk approaches make

the issue of developer bias more difficult to deal with. This kind of bias occurs when developers knowingly or unknowingly skew the designs and software architecture of TEL environments towards their own preferences and instincts which would most certainly be influenced by their cultural backgrounds. For situations where the developer is native to the target culture the bias might not be so severe. However, when there is a mismatch as discussed in [4], a culTEL environment can be seriously affected to the point of being irrelevant and even offensive.

Therefore, we argue that all three perspectives need to be equally addressed through the use of computational frameworks that have been grounded in formal cultural models and theories that structure culture at appropriate levels of granularity suitable for the culTEL environment being developed. Another suggestion for avoiding the pitfalls of folk approaches is given in [4] who describes a three-step methodology for building interactive enculturated systems using these models in conjunction with empirical human evaluation.

3.3 Intracultural and Intercultural Assessment

Another challenge that culTEL research must deal with is the greater need for system assessment and performance evaluation with actual users. For instance, acquisition-oriented culTEL environments are routinely assessed for intercultural effectiveness with users who want to gain communication and language skills in order to interact seamlessly with members of particular cultural groups. We argue that intracultural tests should also be done using native cultural group members even if the goal is intercultural communication. This dual form of assessment promotes balanced cultural designs from emic and etic perspectives [25] and can also be applied to adaptation-oriented systems for tests of authenticity and relevance. Furthermore, this approach gives insight into the kinds of learning situations where degrees of cultural blindness can be tolerated a little, a lot, or not at all. Lastly and most importantly, performance evaluation is crucial since many claims are made about the benefits of cultural awareness but there are few cases with supporting empirical evidence. Whether the goal is increased learning gains, behavioural change, motivational triggers or skill acquisition, some form of experimental evaluation is necessary when culTEL environments are proposed.

4. Research Directions

One of the overarching goals of culturally-aware TEL research is the production of an as-realistic computational representation of culture at individual and group levels which can be applied to educational systems at different software levels (interface, application layer and data layer) for different manifestations (virtual agents, gaming environments, tutoring systems) with the intention of promoting compelling learning experiences that resonate with students. The research projects described in Section 2 are significant because each piece of work tackles a small piece of the puzzle towards this big goal. Although many challenges still exist such as cultural data collection and

effective culTEL system deployment, the breakthroughs that have been made will be uniquely positioned for uptake by practitioners as cultural awareness becomes a mainstream design requirement in educational software.

Threads of similarities are becoming apparent across the research being conducted in the field and some focused research directions are emerging with distinct objectives. The first direction is the modeling of student cultural contexts which focuses on the portability of cultural knowledge and the generation of realistic, accurate multi-layer models of student context that quantify degrees of membership to one or more cultural groups. A second research direction is the development of realistic cultural peers intended as learning companions, advisors and even instructors. Here the focus is on capturing cultural behaviour and language that naturally adjusts to the student's mood, gestures and verbal language. A third research direction is the on-demand, real-time production of contextualised content and adaptation of interfaces and system appearance. The focus in this case is on dynamic, flexible localisation of the educational content and system behaviour which can be controlled by the students or intelligently by the culTEL environment.

5. Conclusion

The advancements in culturally aware TEL research that have occurred over the past five years are opening up many possibilities for the development and deployment of culturally enhanced learning environments. Breakthroughs have been made in conceptual models of culture, student cultural contextual modeling, adaptive techniques, and embodied conversational agent technology. Coupled with increasing interest in making TEL culturally aware, these developments are setting the stage for widespread uptake of localized designs which will become essential as TEL continues to grow with international markets. There are still many weak points and open issues in culTEL research that require deeper investigation and caution is necessary when adopting techniques that have not been engineered with instructional goals in mind. However, promising research directions formed by clusters of related work have the potential to address these challenges and produce sophisticated culTEL environments that cater for diverse student backgrounds.

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