# Culturally Adaptive Software: Moving Beyond Internationalization

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**Abstract.** So far, culture has played a minor role in the design of software. Our experience with *imbuto*, a program designed for Rwandan agricultural advisors, has shown that cultural adaptation increased efficiency, but was extremely time-consuming and, thus, prohibitively expensive. In order to bridge the gap between cost-savings on one hand, and international usability on the other, this paper promotes the idea of *culturally adaptive software*. In contrast to manual localization, adaptive software is able to acquire details about an individual's cultural identity during use. Combining insights from the related fields *international usability*, *user modeling* and *user interface adaptation*, we show how research findings can be exploited for an integrated approach to automatically adapt software to the user's cultural frame.

## 1 Introduction

One of the largest impediments for the efficient use of software in different cultural contexts is the gap between the software designs - typically following western cultural cues - and the users, who handle it within their cultural frame. The problem has become even more relevant, as today the majority of revenue in the software industry comes from outside market dominating countries such as the USA.

Research conducted on the effect and usability of culturally adapted web sites and interfaces has already shown enormous improvements in working efficiency [1-4]. These results were further emphasized in our experience with *imbuto* [5], a program designed for Rwandan agricultural advisers (see Fig. 1). The conceptualization of *imbuto*'s learning platform, which holds information about newly-developed methods for increases in agrarian productivity, was accomplished on-site in Rwanda. In particular, this allowed for a circular development: To begin with, we thoroughly investigated the cultural particularities of the target group with the help of interviews and questionnaires. The result was a first version of *imbuto*. As a next step, the software was alternately enhanced and tested with Rwandan subjects. Since the provisional test system was designed and implemented by a member of western culture, evaluations soon revealed that Rwandans could not optimally use the software in terms of information perception and handling. We observed that difficulties emerged from too much freedom in the choice of functionalities: Rwandans, who learn to strictly follow instructions from a young age, seemed to be

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overwhelmed by the range of functionalities available in the software. A playful arrangement of constituents, allowing for explorative behaviour, and a colorful user interface with a realistic appearance, were further adaptations that were needed for reconciling the software with the target culture.

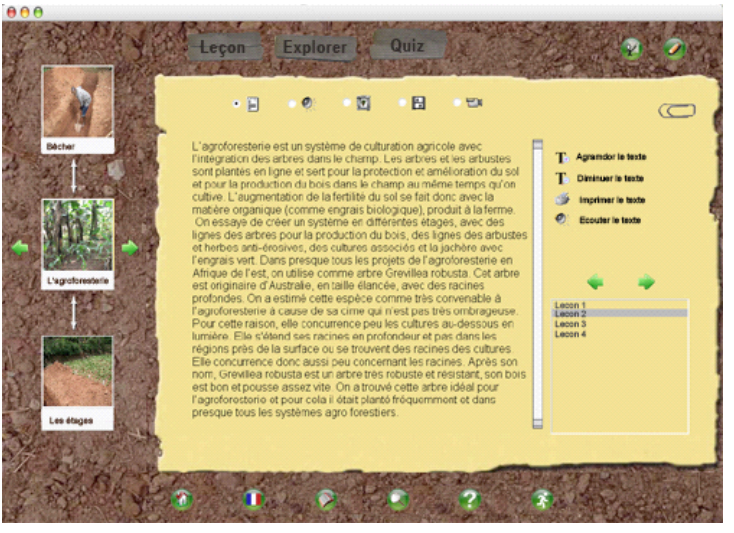


**Fig. 1.** Learning Platform for Agricultural Advisors in Rwanda

After these extensive circular adaptations to the cultural frame of Rwandans during a time span of approximately five months, evaluations finally fulfilled the expectations of improved usability and a reduction in time required for familiarization with the software. However, extending the target group to other cultures would necessitate even greater time.

Hence, cultural adaptation of software reveals two major problems:

1. The development cycle is extremely time-consuming, making it prohibitively expensive.
2. The elusive nature of cultural background makes it hard to recognize one's own preferences and thus, where the system should be adapted [6].

For economic reasons, software manufacturers therefore often neglect cultural adaptation that goes any further than a mere localization of the interfaces, such as the adaptation of language and date format.

One answer to general adaptation problems proposed by Maier [7] is the use of adaptive or personalization systems that "represent the most promising solution to the contradiction between striving to achieve cost-savings on the one hand, and high-quality training and customer satisfaction on the other". Extending this to the problem of cultural adaptation, we propose to approach the issue by developing *culturally adaptive software*.

Essentially, the idea of culturally adaptive software spans inter-disciplinary research fields that underlie the premises of successful Human-Computer Interaction.

In order to reveal the culture-dependent components of software, it is necessary to build a user model based on cultural particularities before the adaptation can be accomplished. In the following, we start with a literature review on international usability and culture. This review is the basis for an introduction on the current state of the art in user modeling and adaptive user interfaces. We will then combine these fields by identifying the necessary components and techniques of artificial intelligence (AI) required for automated software culturalization. The paper closes with the presentation of our research plan for culturally adaptive software.

## 2 Culture and Usability

Previous research indicates that usability can be only assured if future systems will be designed culture-oriented [8]. These evaluations showed improvement and an increased user acceptance through manually localized interfaces. However, they were not yet able to persuade the software industry of the positive economic effect of an increased consumer acceptance.

Over the last two decades, cultural usability research primarily focused on the cultural dimensions developed by the cultural anthropologist Hofstede [9, 10]. His classification of culture predicates on differences in cultural values. He points out that particular responses are "more likely in certain cultures than in other ones" [10]. In recent years, evaluations applying his cultural dimensions include studies by Voehringer-Kuhnt [11], Marcus [12] [13], Dunn and Marinetti [14], Dormann and Chisalita [15], Ford and Gelderblom [3], Hodemacher et al. [4] and Kamentz [16].

Hofstede's dimensions also built the basis for studies conducted in the area of *culturability*, a brigading term invented by Barber and Bardre [2] for "the merging of culture and usability". They also defined the so-called "cultural markers": elements of an interface that are preferred by a specific culture. Analyzing many hundreds of web sites, they found that cultural markers strongly influence the usability of software interfaces.

Hofstede's dimensions were enhanced by many researchers including Trompenaar who coined the metaphor that culture is like an onion consisting of many cultural layers [17]. Dunn and Marinetti [14] used Trompenaar's additional cultural dimensions to point out that one must peel this onion "to get to the core values, the things that really matter" in order to plan for cultural adaptation. Later, Marcus [18] developed a set of cultural dimensions by ranking a given list of these dimensions with the help of 57 participants from 21 different countries around the world. Doing so, he was one of the first researchers to attempt to build a bridge from evaluations on culturability to their application. The outcome was a practical set that can be used as a preliminary user model.

Nevertheless, research conducted in the interdisciplinary field of culturally adaptive user interfaces cannot presume that generic models of culture can be simply applied to the area of user interfaces. After measuring Hofstede's dimensions in an evaluation, Smith and Chang [10] are apprehensive that "in the case of China the four Hofstede dimensions have greatly differing significance". Some researchers also criticize the employment of cultural models as too generalizing and stereotypical [19]. Regarding the rigid one-to-one mapping of a single culture to a whole nation, as

exemplified by Hofstede, the adaptation to culture in its redefined meaning for our globalized world is indeed questionable. However, concerning an initial user classification, we suggest using this simplistic view as a starting point from where adaptivity algorithms will refine it stepwise to cross-cultural particularities. These would then be assignable to people who belong to a single culture, as well as to culturally ambiguous users.

## 3 User Modeling

While it is increasingly encouraged to consider culture in interface design [1, 12, 20-23], various branches of research have concentrated on ascertaining "cultural fingerprints" in an interface [10]. Nevertheless, little progress can be found on combining these with an actual strategy about making predictions about the cultural background of users. Recently, Kamentz [16] looked into this new direction by investigating components needed for cultural user modeling. She states that cultural adaptation must be considered in the context of the user's background, while knowledge, aims and plans, preferences and individual user properties form important attributes that are to be modeled, but do not as such involve the cultural component. Apart from learner specific adaptivity, she also investigated layout, interaction and navigation and its cultural particularities in her studies.

However, to date it is still a moot point of how culture can be comprised in the construction of a user model. Moreover, it is unknown which methods to use in order to automatically acquire culturally related facts about individual users. Kobsa, who has been one of the key researchers in the area of automated user modeling, states that useful methods for user modeling strongly depend on the application domain of a system and are often combined [24]. Consequently, it can be assumed that current methods are widely applicable to cultural user modeling. We will therefore discuss the most common methods for the acquisition of user models in the following section, before returning to a discussion of our "cultural problem".

### 3.1 Acquisition of User Models

A key concern when ascertaining user modeling information, is whether data should be gained through an integrated acquisition process in the background, or through separate acquisition that is discrete to the normal interaction between the user and the system [25]. So far, almost all organizations of user groups into common characteristics with *stereotypes*, or into common interests with *communities*, as suggested by Paliouras et al. [25], have been carried out manually. This is not only difficult because it "involves the classification of users by an expert and/or the analysis of data relating to the interests of individual users" [25]; for cultural user modeling, manual acquisition is also questionable due to the intangible perception of cultural values and is therefore only feasible for an initial classification.

Such challenges in the manual construction can be abated by making use of *user modeling shell systems* that are similar to expert systems in Intelligent Tutoring Software. Shell systems offer a number of integrated mechanisms for user modeling. They still require the provision of primary assumptions about users [26], and thus

involve separated acquisition. However, they take on all essential functions of a user modeling component of a system, "including user model representation, inference on the basis of the user model, consistency maintenance, and automatic user classification" [24] by shifting the mostly heuristic acquisition rules onto the shell.

Further endeavors towards automated acquisition have been made by the use of *machine learning techniques* for the automatic acquisition of data for the user model [25, 27, 28]. Given their wide use in personalization (see, e.g., [29]), machine learning algorithms are able to manage user models, supporting the automatic acquisition and constant updating of data [30]. Hence, they are useful for automated cultural adaptation.

An alternative strategy for user modeling is the *interaction history method* that is suitable if a continuative analysis of users is not applicable [24]. By monitoring the user, the system collects data about the interaction behavior before using clustering techniques to group this information. Clusters will then be classified and linked with a user group or an interaction, thereby generalizing the information to "interaction patterns" [31].

Focusing on our problem of *cultural user modeling*, we propose the use of stereotypes and communities that are highly beneficial for an initial (though very rough) user classification. By incorporating existing cultural models from other disciplines, this approach helps to outperform costly manual internationalization. The user's country of origin and his language, for instance, already provide first hints of their cultural cues and can activate an assigned interface layout. However, the acquired profile at this stage is unlikely to correlate with all facets of the user's culture. As a consequence, their interaction with the system has to be continuously monitored and evaluated in order to refine the assumptions about the user's cultural scope. Such further acquisition and step-wise refinement of stereotypes and communities has been proven to be successful with the help of established machine learning methods [25]. As described above, tasks such as those involving the maintenance of the user model are suited to be taken over by a shell system.

After these considerations of user modeling techniques, it can be assumed that cultural user modeling can take advantage of existing approaches to user modeling that base on AI techniques. However, such a combination of methods and in particular linking them to software adaptations, has yet to be studied in practice. To that end, the next section will introduce the work on user interface adaptation (i.e., methods for the dynamic re-arrangement of user interface elements), which will pave the way for integrated culturally adapted approaches.

## 4 Adapting the User Interface

Although the theoretical concept of adaptive computer systems has been an important subject for the research community, most approaches have been applied to adaptive hypermedia (or web) systems and only involve "the level of the content of the provided information (as opposed to the level of information presentation at the interface)" [24]. One reason for this might be that the advantages and disadvantages of providing generically filtered information are relatively easy to evaluate. Besides, it can be assumed that the objections to adaptivity at the user interface level also led to a

stagnation of research in this area. In reference to this, Shneiderman [32] points out that „machine initiated changes to user interface features seem to be troubling to users“.

Nonetheless, much research supports the thesis of user performance improvement with the help of adaptive interfaces (see, e.g., [33], [34] or [35]). If doubts persist, it is because none of these results can to date be readily generalized. Thus, many objections stem from "a fear that intelligence at the interface will violate usability principles" [36]. An important issue in this regard is the choice between automatic or computer-supported adaptation, the latter leaving more control to the user. Kobsa [26] points out that computer-supported adaptation is the better alternative if adaptations only seldomly occur but are nevertheless more important. This is fundamental for changes of the user interface since the users attention might have to be drawn to the new possibilities [26].

Regarding culturally adaptive interfaces, we have to keep in mind that most users are not used to an adaptation to their cultural frame, but have become acquainted with software embedding western cultural values. Thus, computer-supported adaptation risks a rejection of cultural adaptation measures before the user might experience its advantages.

We suggest to *automatically* adapt the software after initially having acquired the user's cultural background. In order to allow users to retract changes at any time, we plan to include an easy-to-access history log of recent adaptations. Further changes to the software should later underlie computer-supported adaptation and allow for the user's intervention if proposed changes are not desired. Here, too, are thorough evaluations essential in order to ensure that users can easily cope with adaptations and the way they are executed.

To clarify the concept of adaptive user interfaces, we will explain the idea behind it in the following section by referring to some developments in the past.

### 4.1 Recent Developments

Recent approaches to adaptive arrangements of interface components include the AVANTI system for disabled users that uses "a single unified user interface" but offers alternative interaction components to suit the user's need [37]. With the help of a rule-based adaptivity mechanism that communicates with the unit responsible for the user modeling, the interface can be adaptively enhanced at run-time.

Menkhaus and Pree [38] developed a new approach to dynamic user interface adaptation by remodeling "the widgets of a window into a new composition of 'small' windows", basing it on a "linking strategy" of two graph hierarchies. This method was originally developed to provide adaptation possibilities for a range of displays, input devices and mobile computing gadgets. Likewise, it has proven to be applicable for the flexible rearrangement of user interface components on the basis of a hierarchical structure of windows.

While the techniques mentioned above can be classified as the restructuring of components with the basic interface remaining the same, several approaches have proposed to offer different interfaces. Shneiderman's idea of a multi-layer design for complex systems, for example, associates the user's experience with a certain

interface layer. It thereby offers the user a lower level with less functionalities or a higher level with an augmented number of interaction possibilities [32].

Regarding the adaptivity strategy, many researchers have proposed to increase consistency between applications. Lennard and Parkes [39], for instance, suggest to re-use the user's model of the interface in all applications. This is a big step towards a holistic usability that is not limited to single applications but instead supports different interfaces in providing a consistent look and feel for the user.

## 5 Heading Towards Culturally Adaptive User Interfaces

After reviewing the current state of the art in the three disciplines of culture & usability, user modeling, and interface adaptations, we find that the distinct research areas have yet to be combined and results have yet to be aligned with one another.

For instance, existing techniques for the initialization and maintenance of a user model can almost certainly be adopted for cultural user modeling. However, we do not know how the transfer of these techniques to culture can be carried out. "Is the user's culture tangible enough to establish a user model?", "How can we distinguish between cross-cultural and interpersonal differences?" as well as "Is it possible to assign one culture to a particular person in our globalized and multicultural world?", are questions that we will only be able to answer after hands-on experience with cultural user modeling and thoroughly investigating the measurability of culture in regard to adaptive user interfaces.

In addition, we have to map certain cultural behavior to an interface layout. It is therefore necessary to identify cultural markers that are universally valid for user interfaces. Again, existing research in this direction, such as the investigations of cultural markers in web site design (see [2, 40, 41]), can be used as a starting point for redefining these elements to suit user interface constituents.

The highly diverse adaptation of the interface can presumably be best modeled by systems that support a modular composition of the interface. Here too, the different possibilities regarding the user interface layout have to be investigated with special attention to established usability guidelines. Factoring in cultural markers, we will have to define the necessary level of flexibility required by individual elements and their composition as a whole. Thereafter, one can deliberate regarding the use and benefit of existing strategies for the adaptation of user interfaces, such as the graph hierarchies developed by Menkhaus and Pree [38]. The approach needs to be flexible enough to support all conceivable culturally adapted interface layouts, but still simple enough in order to avoid unnecessary overhead in adaptation complexity.

If we manage to merge research on culturability with guidelines on the usability of adaptive user interfaces (see [36, 42]), we will be able to develop culturally adaptive user interfaces that follow established culturability rules.

## 6 Conclusions and Future Research

In this paper we have proposed to overcome the problem of missing "culturability" with culturally adaptive user interfaces that enable people to use software within their

cultural frame. Our opinion is that culturally adaptive software is the only possibility to overcome the two main problems of manual localization, which are, firstly, the extremely laborious and costly development process and, secondly, the elusive nature of cultural background.

Introducing artificial intelligence to the internationalisation of user intefaces makes it possible to provide a highly flexible interface adaptation that avoids to stereotypically assign a static layout to all users. Automizing the process of internationalisation throughout the use of the software will therefore allow for a less laborious and costly development.

We have presented a research summary of the core issues surrounding culture & usability, user modeling, and the adaptation of interfaces, and identified possibilities for combining these areas to achieve a concerted effort towards the topic. There are still many open questions and challenges facing the merging of different research disciplines. Consequently, our future research will firstly involve an analysis of cultural markers for software adaptation in order to establish a procedure for the software engineering and design process. With this, we will also outline how the software's architecture has to be designed to allow for an adaptation to different cultures. Furthermore, it is essential to find suitable knowledge representation techniques for the user model, as well as adaptivity strategies.

We intend to develop a prototype system in a participatory design process to test the most promising adaptivity algorithms over a longer time frame with members of different cultures. These evaluations will ensure an overall high quality of culturally adaptive software without significant investments of software-engineering resources.

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