Adaptability and Adaptivity in Learning Systems

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Abstract

A good learning system may need to provide a protected learning environment (by restrictions or by warnings) to facilitate efficient learning to the students. From the human-computer interaction point of view a careful examination is necessary of how to adapt the learning environment to the learner's goal and capability in such protected situations. This paper discusses the applicability of *adaptability* and *adaptivity* features to fulfil this purpose. The paper also discusses the adaptation needs of learning systems, with particular attention on *Intelligent Learning Systems* (ILS) by their comparative study with office application systems, which have been an important area of research in the field of adaptation facilitation.

Keywords: Adaptability, Adaptation, Adaptivity, Intelligent Learning Systems, Learning Systems, Office Application Systems

Introduction

The concept of adaptation has been an important issue of research for learning systems in last few years. The research has shown that the application of adaptation can provide better learning environment in such systems but many research issues need to be resolved before an effective and efficient adaptation in learning systems is possible. This paper investigates and discusses various issues concerning the applicability of adaptation for learning systems.

There have been many attempts in the last decade to include user models and adaptation features within systems with a view to improve the correspondence between user, task and system characteristics and increase the user's efficiency. Two kinds of systems have been developed for supporting the user in his/her tasks. Systems that allow the user to change certain system parameters and adapt their behaviour accordingly are called *adaptable*. Systems that adapt to the users automatically based on the system's assumptions about user needs are called *adaptive* (Oppermann, 1994). The whole spectrum of concept of adaptation in computer systems is shown in figure 1.

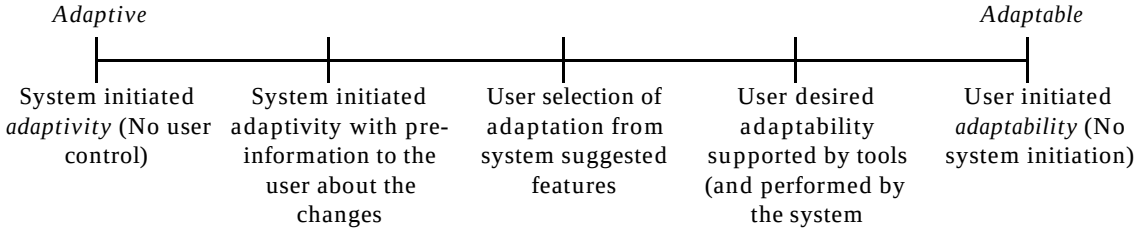

Figure 1. Spectrum of adaptation in computer systems

The next section discusses the main objectives of learning systems and describes how the adaptation can be useful to complement their objectives. This is followed by a comparative study of learning systems and office application systems from the adaptation point of view. This comparison provides the background for the

application of *adaptability* and *adaptivity* for learning systems which is presented in following section. The paper finally discusses some aspects related to the effectiveness of adaptation (the word 'adaptation' in this paper includes both *adaptability* and *adaptivity*) specifically in Intelligent Learning Systems (ILSs) and points out some problems which need to be resolved.

The objectives of learning systems

The main objective of a good learning system is to provide efficient learning to the students, who may or may not have prior exposure to the subject content and may also be less experienced in reflecting their learning experiences (novice in terms of meta-learning aspects) due to limited prior academic instruction (Kinshuk & Patel, 1996). Hannafin & Peck (1988) provided some characteristics of a good (effective) CAI system, such as effective CAI is based on instructional objectives; it matches learner characteristics and maximises interaction; it is individualised; it maintains learner interest and approaches the learner positively; it provides a variety of feedback and evaluates performance appropriately; it uses the computer's resources wisely and is based on principles of instructional design; and, an effective CAI has been evaluated thoroughly before use.

Though this list by Hannafin & Peck (1988) is concerned with whole life-cycle of an instructional or learning system, the main focus is on the effective and efficient knowledge acquisition by the student from using the system. One way to achieve this aim is to provide a protected learning environment (by restrictions or by warnings), which allows the student to perform appropriate patterns of tasks. From the human-computer interaction point of view, this aim needs a careful examination of how to adapt the learning environment to the learner's goal and capability. Such adaptation can be provided by *adaptability* and *adaptivity* of the systems.

The *adaptability* and *adaptivity* has been explored by researchers at many occasions for office application systems and many current office applications provide adaptation features at least at their basic levels, if not very sophisticated. Though there are various significant differences between learning systems and office application systems for task accomplishment which influence the requirements for application of adaptation features, such as the usage time-span, availability of standards, differences in aims, functionality, requirements and so on, it would still be beneficial to compare the learning systems with office application systems from adaptation point-of-view in order to analyse the requirements for *adaptability* and *adaptivity* for learning systems.

Learning systems vs office applications systems

Edmonds (1987) described five areas the system can take into account while considering adaptation: user errors, user characteristics, user performance, user goals, and the information environment. Though both application systems and learning systems need to care about these factors, the emphasis of adaptation is different in both types of systems. Oppermann (1994) divided the criteria of adaptation in two main topics: *adaptations of functionality*, which covers options for adapting the range and behaviour of the features of a system, and setting up trigger options; and *interface adaptations*, which includes the options for modifying the access to these features, their interactive dynamics, and their use of screen layout. The following discussion presents a comparative study of office application systems and learning systems.

The office application systems are generally data processing applications. Their main uses include creation and editing of documents. The consideration of adaptation in

these systems is based on *object creation and editing*. On the other hand, the learning systems have prevalence of navigational commands rather than data processing. Therefore the consideration of adaptation is based on *object properties understanding*.

The office application systems are expected to be used for long time with repeated use. Therefore it is desirable that the system facilitates *adaptable* features to the user as well as tries to adapt according to the user (*adaptivity*). The learning systems are generally used for short time with less repetitive use. Their use is limited to the period the students have grasped the subject content presented by them. Therefore, by the time, the system would make any inferences about the students' preferences and needs, the students would have already finished using the software. In this scenario, the application of *adaptability* in learning systems is restricted to a couple of selections or definitions, like learning level (expertise), instruction language and so on, though the provision of *adaptive* features may enhance the effectiveness and efficiency of the learning systems.

The office application systems, due to their extensive use, are enforced to use following *de-facto standards* (Swann et. al., 1992):

a) *Operation Systems de-facto Standards*: The wide use of certain operating systems results in some commonly accepted guidelines. The applications running in that environment are enforced to accept and adopt these guidelines to provide familiarity of use to the user.

b) *Application de-facto Standards*: Due to large uses of some particular applications, many *de-facto standards* appear in the field (for example, Microsoft product's interface and functions). New applications in that area are then enforced to adopt these unwritten guidelines in order to get acceptance in the market (Rashev, 1994).

These two *de-facto standards* facilitate less cognitive load on the user in terms of learning the use of software. They also facilitate the collaboration and knowledge sharing among user community.

On the other hand, the usability of learning systems is not strongly effected by existing *Operation Systems* or *Application* de-facto standards due to following reasons:

a) Learning systems in different domains have different requirements and different objectives / goals.

b) The user community of a particular learning system is not very large.

The absence of de-facto standards for learning systems suggests greater need of adaptation features in these systems to reduce cognitive load of the users, which otherwise would be facilitated by the de-facto standards.

It is often easier to provide *adaptability* features for office application systems by incorporating various well-established metaphors which facilitate the users with easy understanding of what is being offered. Since there are no established metaphors for the learning systems due to varying functionality from domain to domain, each learning system requires special consideration with respect to adaptation. *Adaptability* features, in this case, would result in more cognitive load on the user.

The functionality of office application systems is generic rather than goal-oriented. The main intention of these systems is to provide comfort and efficiency to the user in achieving their own goal. The learning systems, on the other hand, are themselves goal-oriented. The main purpose of the learning systems is to provide adequate learning of a particular subject. This requires system initiation with some restrictions on the part of the user. Therefore, some *adaptivity* features should be provided in

Intelligent Learning Systems at interaction and interface level in co-operation of tutoring strategies in order to minimise the user's discomfort.

The application behaviour of an office application system is caused from 'user's actions' and 'adaptivity model' (if exists). The systems apply user modelling to make decisions about users' preferences and predicts the next possible action of the user. On the other hand, though, the application behaviour of a learning system is caused from 'user's actions' and 'adaptivity model' (if exists), the Intelligent Learning Systems also contain an 'instructional planning model'. Student modelling is used in such systems to infer about students' level of understanding of subject matter, besides their preferences about application behaviour.

Both, office application systems and learning systems have similar adaptive strategies in inferring user's behaviour and predicting user's next actions. The adaptive strategies in the office application systems are also reflected in the actions taken by the system to fulfil user's assumed needs. Such *adaptivity* can also be provided in the learning systems. In the Intelligent Learning Systems, the intelligence is reflected in tutoring strategies undertaken by the system for efficient and effective learning, which should not be misunderstood with the concept of *adaptivity*.

Application of adaptation in learning systems

As mentioned above, both *adaptability* and *adaptivity* features can be incorporated in learning systems at different levels of functionality and representation with varying effectiveness. The following discussion highlights the applicability of adaptation features in the learning systems and points out the associated problems. Only a few examples of the *adaptability* and *adaptivity* implementation are discussed.

Many researchers have noted that *adaptable* features, such as tools for adapting the user interface, are hardly ever used by novice users and are used only to a limited degree by experienced users (Jorgensen & Sauer, 1990). These features place certain type of cognitive load over the users which keeps them away from their main task of learning. Since the learning systems are expected to be used for short-term, it is advisable to let the system adapt itself (*adaptivity*) according to the user rather than forcing the users to change the system behaviour (*adaptability*).

It should, however, be noted in above discussion that the users of learning systems can be provided with *adaptable* features related to the interface as audio adjustment, selection among various alternatives of control objects which provide same functionality, display pattern of the system messages and feedback and so on, as long as these features do not interfere with system's main objective (for example, with tutoring strategies in intelligent learning systems).

Specifically, the *adaptivity* features in non-intelligent learning systems can be provided at both user level and at task level. At user level, for example, the adaptation in the explanation granularity can be associated with user's frequent demand of some particular granularity level replicated at other places, where it is not demanded but expected to be intended. At task level, the user's preferences for a task can be used in completing various tasks of similar nature.

With increasing growth of distance education and other alternative means besides the traditional classroom education, the current learning systems are being used both on individual (dedicated computers) and shared basis (such as laboratories). Both situations have different requirements and effects of *adaptability* and *adaptivity*. There is not much difference in individual and shared scenarios if the user profiles can be

saved and used at later stages but this forces the learning systems to be network-based.

In individual situations, such as in distance learning, the *adaptability* features are result of user's own actions and not of someone else, which may be the case in shared laboratories with no user profiles. Once the system is configured at individual computer, there is no need to configure it again. In fact, if the installation procedure sets various features according to user's preferences, there is no need to even know the technicalities of the configuration mechanisms. On the other hand, the application of *adaptability* in individual situations may lead the student to a self-created unfamiliar situation (such as removal of certain functionality from the interface or appearance of unfamiliar information) giving a feeling of isolation due to the absence of peers.

The application of *adaptivity* on individual dedicated computers leads the applications to adapt the user once and then no changes are needed till the user's preferences are not changed. But in shared scenarios with no user profiles, the system will not be able to provide the adaptivity features from the beginning of the session. The system will either start with some default features in every session and will try to adapt the user (which means the effectiveness of the adaptivity is significantly less) or will provide the adaptivity features based on the information inferred from previous user(s), which again is not a desirable situation.

Though the provision of *adaptability* and *adaptivity* may be easy in the Intelligent Learning Systems since the user's goals are predetermined, these adaptation features may conflict with the intentional restrictions imposed by the system on the student to enforce certain types of tutoring strategies. The next section reviews some of these aspects and discusses the possibility of facilitation of adaptation features in the form of *adaptability* and *adaptivity*.

Intelligent learning systems and adaptation

Traditional Intelligent Learning Systems (ITSs) adapt the learning process for individual students (Aimeur et. al., 1995) by applying appropriate pedagogical strategies in interacting with the learner and presenting domain knowledge. The main concern remains on learning which means the system may restrict the user from certain tasks or advise to do certain tasks as recommended by pedagogical strategies whether or not they match with user's preferences.

As discussed earlier, the issue of adaptation is quite different for intelligent learning systems and office application systems. Since the office application systems works as a tool to support the user's main tasks or objectives, the issues of social monitoring and privacy-protection demand that the application of adaptation remains in user's control (*adaptability*). In intelligent learning systems, the main task-objective of learner's adequate knowledge acquisition remains with the system and the system needs to monitor the user's actions to facilitate appropriate tutoring strategies. Therefore, the application of *adaptivity* is not restricted in such systems.

Due to various restrictions and risks posed by *adaptivity* features of the systems (social control posed by the system on the user, system's monitoring of user, pressure on user to adapt to system developer's conceptual model, and so on) many authors have suggested (Grunst et. al., 1996) that *adaptability* should be the first choice to provide adaptation features within an office application system and to combine the adaptation features with user control. This can be done by (a) providing means for the user to activate and deactivate adaptation of overall system or part of the system at every stage; (b) allowing the user to accept, modify or reject every or any part of proposed adaptation; (c) enabling the user to specify adaptation parameters; (d)

informing user about the proposed changes due to adaptation before actual change happening; and (e) giving the user sole control over his/her behaviour records and their evaluation.

The above suggestions do not match with the underlying objectives of an intelligent learning system. To provide adequate knowledge acquisition, the system requires to evaluate the user's behaviour without letting the user to modify the system's assumptions about his/her behaviour at will. Various tutoring strategies need to be presented which at occasions may give a feeling of restriction to the user. But the user should not be allowed to act against it, or at least warned if user's actions do not suit to these strategies. Many times, the user is not able to infer about his/her understanding of the subject matter and may have different opinion from the system about it. In such situations, the system requires to verify the user's opinion with substantial inferences (for example, via direct dialogue or through machine learning approaches). In other situations, the system may require to put the users in little unfamiliar scenarios, to test their ability of abstraction of concepts learned so far. In such cases, it is not possible to inform the user in advance about the changes on the screens or in the functionality, which are about to happen. And certainly, it is not possible to facilitate the user with overall control over the system.

It seems from the above discussion that for intelligent learning systems, it would be better to provide *adaptivity* features rather than *adaptability*, in order to achieve the objectives of the intelligent learning systems, while still allowing various adaptations according to the individual user's needs. The *adaptable* features may be provided in intelligent learning systems for some aspects such as interface and navigational preferences which do not put adverse effect on tutoring strategies.

Discussion

This paper presented an initial research report on the applicability of *adaptability* and *adaptivity* in learning systems. It was identified that in contrast to office application systems, where both of these adaptation features are applicable and *adaptability* is recommended, in learning systems, the application of *adaptivity* finds more suitability than *adaptability*. The conflict between adaptation features and tutoring strategies in intelligent learning systems is identified with a clear need of future research work in this field.

Note

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