Initialising a cognitive user model of memory within a mobile game

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Abstract

This paper describes a novel way of initialising an individual user model concerning this particular user's retention capabilities. The initialisation is obtained through a simple memory game that the user has to play for some time. Thus the memory game is considered as an initialisation application. The initialised user model may then be used in another application, the target application, that needs to have information about the user's retention capabilities. Such application may be an Intelligent Tutoring System (ITS) that models the student's cognitive state and the way s/he learns. In this way, the memory game application serves as a pleasant way for the initialisation of the student model which collects information concerning the memory retention capabilities of the player according to a cognitive psychology model of human memory. The game is easy, small and portable, being able to run everywhere even in mobile phones, more specifically smart phones.

1 Introduction

Personalisation and adaptivity are desired characteristics for software applications that are addressed to a wide range of users of various backgrounds capabilities and needs. These desirable features in user interfaces may be achieved if we have user models inside the software applications. Applications that may benefit a lot from user models are Intelligent Tutoring Systems (ITSs). In such cases user modelling is learner modelling. Learner modelling involves the construction of a qualitative representation that accounts for student behaviour in terms of existing background knowledge about a domain and about students learning the domain (Sison & Simura, 1998). Such a representation, called a learner model, can assist an Intelligent Tutoring System (ITS), an Intelligent Learning Environment (ILE), or an intelligent collaborative learner in adapting to specific aspects of student behaviour (McCalla, 1992).

User modelling requires collecting information about each user so that several aspects of his/her state may be modelled. This means that a system can only achieve an accurate user model after the user has provided explicitly and/or implicitly information about him/her. When a new user starts interacting with an application then the system must initialise the user model which is then refined when more information about the user is known. The initialisation of the user model is extremely important because if the user model is initialised incorrectly then the application may lose its credibility from the first interactions with the user. Although a lot of research work has focused on the identification of efficient methods for updating the user model, the process of the initialisation has often been neglected or it has been dealt using trivial techniques. One common way for the initialisation of user models involves the user answering to questionnaires. However, questionnaires cannot be too long because users may find it very tiresome to answer them. Moreover, users may not be able to describe themselves as accurately as it would be needed.

In view of the above, the aim of the research described in this paper, is the initialisation of user models concerning user's memory retention capabilities through a pleasant and user-friendly memory game application. The game provides the asset of not being tiresome and if it can be played in any place, it does not have to take up any productive time of the user. Rather, it may be played at leisure time. Thus the game is implemented in such a way so that it is small and portable, being able to run everywhere even in mobile phones. This game incorporates a cognitive psychology model which measures the user's memory retention capabilities. The cognitive psychology model is based on a classical approach on how people forget by Ebbinghaus which appears in a reprinted form in (Ebbinghaus, 1998).

2 The game as an initialisation application

It is widely accepted that one of the most popular ways of human-computer interaction is a computer game. Thus humans tend to react more naturally to the interaction with a game than with any other kind of application. The same stands for the output that may be collected from experimenting with someone abilities. The data that the computer may acquire when testing a subject inside a natural and friendly environment, such as a game, is by far better than the data collected using for example a simple questionnaire.

The game serves as an auxiliary application that aims at producing output about the user's retention capabilities. Thus, the game serves as an initialisation application for the user model. The output produced by this game may be imported to another application, the target application, which needs a model of the user's retention capabilities. Such application can be an ITS. The initialisation procedure is illustrated in Figure 1.

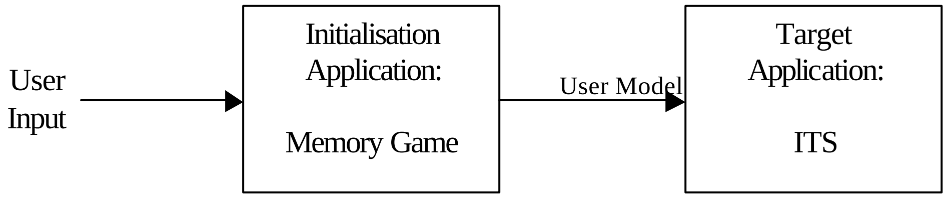

Figure 1. Initialisation procedure through the memory-game

2.1 "Two-of-a-kind"

The application that was selected to use the cognitive model is a simple memory game known as "Two-of-a-kind". This game is a very popular mind-game and a very simple one too. The player starts with a number of "cards" placed in front of him/her upside-down. These "cards" are grouped into pairs which have the same image. Taking turns, the player is asked to flip two cards at a time. If both cards of the pair that he/she has chosen bear the same picture then the "cards" remain flipped while the player proceeds to the selection of the next pair of cards. If, on the other hand, the cards of the pair do not bear the same image, the cards are flipped back to the upside-down position and the player is asked to select another pair. In this game the user's goal is to find all the images that match, revealing the whole board. Screenshots of this game can be viewed in Figures 2 and 3.

This game is quite well-known and has been packaged by the game companies in various different forms. It is solely based on the players' pattern matching and short memory retention capabilities. Other variations of the game include timed challenges where the player is required to complete the board not only successfully but also as fast as he/she can by making the fewest possible mistakes. It is clear that if we assume that the player does not find any pair by luck then s/he will need to at least flip all tiles once (thus making N mistakes, where N is the amount of pairs inside the board), and then match all pairs unerringly. This gives us the best result of N mistakes, by someone with "photographic" memory.

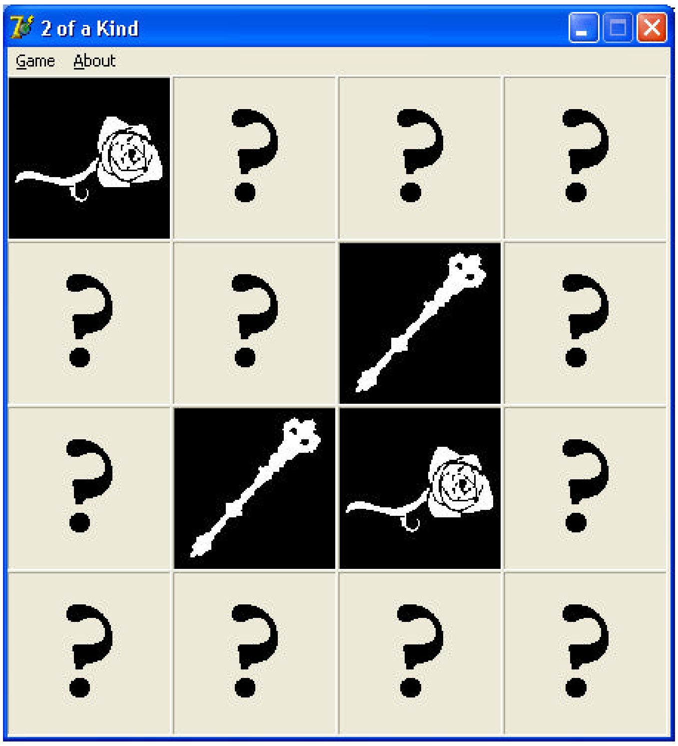

Figure 2. Client Screenshot of the memory-game

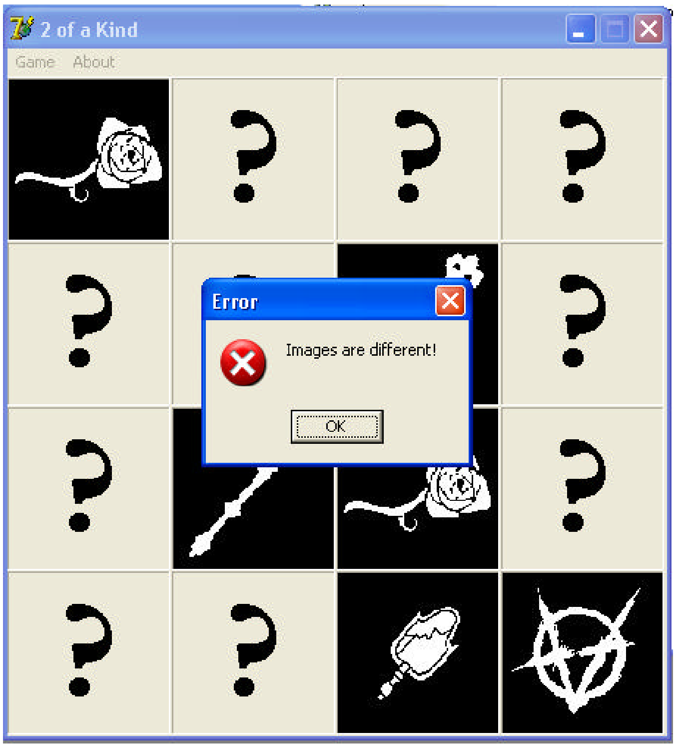

Figure 3. Client Screenshot of the memory-game

2.2 Implementation Architecture

Technically the application “Two-of-a-kind” has been developed using a Microsoft SQL Server as the back-end and Microsoft .NET technology for the framework. We have used 2 layers of application development. The first one is an application server that handles all the functional logic of our application. It is the one holding all the necessary modules that simulate the Ebbinghaus’ cognitive model. The advantage of using an application server is the fact that one does not need to rewrite the actual functional processes of the application, but only the front end. For example we have created an application in Delphi which acts as a client to the specified application server (Figures 2, 3). Furthermore we have created a collection of ASPX web pages which can provide a front-end either in normal HTML pages (thus being able to be viewed by usual Web browsers like Netscape, Internet Explorer, Mozilla etc.) or in HTML pages specifically designed for mobile devices (like cell-phones or palmtops) that have the ability to surf the internet. Figure 4 illustrates the system’s architectural design.

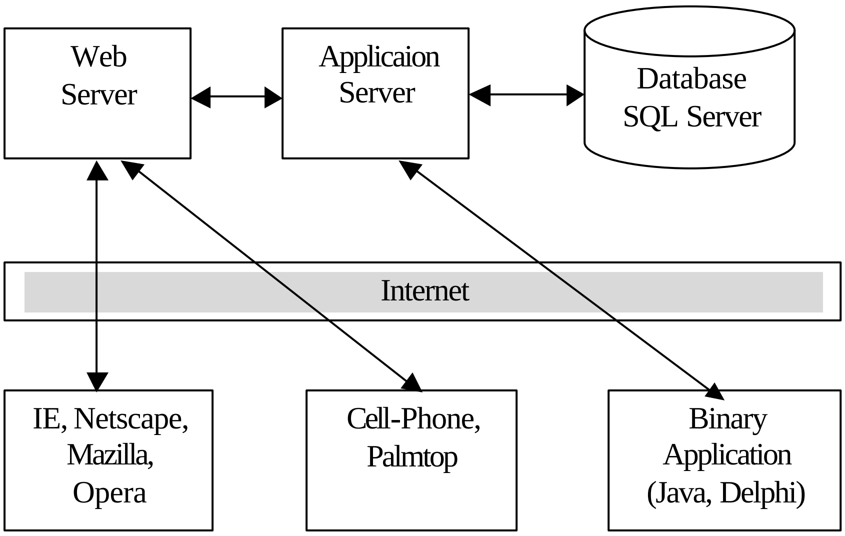

Figure4. System Architecture

3 Cognitive Model

Behind this simple game we have incorporated a powerful cognitive model that can measure the retention capabilities of the player. Based on the research studies of Ebbinghaus (1998), who gave a mathematical formula that could simulate the learning curves of the human brain, we extended the model so that it could be implemented and used in a user model.

3.1 Retention Capabilities

While the user plays the game, the cognitive model measures his/her retention capabilities and creates a user retention profile. If the user is playing the game for the first time, then the first statistics are gathered and an initial user model is calculated. During each subsequent play of the game, along with the player, in the background the application tries to simulate the user’s choices using the previously generated user model. If these choices are very different from the user’s actual ones then the user model is modified accordingly. This process is performed in silent while the user plays the game unobtrusively. This process keeps repeating itself until the user model is stabilised, at which point the system has collected enough data to be able to model the user’s retention capabilities accurately.

During the process of acquiring data extensive effort has to be put on the separation of the “luck” factor from the actual data. When dealing with such mind games, apart from the retention factors one must always keep track of the data that are being compromised by the fact that the player was just “lucky”. In this application there are many different ways to find out which of the data are “true” and which are the “lucky” ones. For example, if a player flips an image for the first time (which means that he/she was in no position of knowing that he/she will find this image underneath), then whatever the outcome is discarded since it does not contribute any information about the user's memory capabilities. The same stands for the last image for which the player actually has no other choice; whether the user had already visited the last card or not, he/she has to flip it because there are no more images to be flipped. As a result this move too does not contribute any information about the user's memory capabilities and therefore it is discarded.

Through experimentation it is concluded that the value of an outcome depends directly on the amount of pairs that have not yet been discovered. At that point one can easily say that if we are to address this problem, we could increase the number of pairs and stop profiling when there are 4 or 5 of them left. However, that approach would lead us again to false data. Given the nature of the game and the fact that the player does not actually gain anything by remembering the positions of the images (in contrast with educational software that the info are related to knowledge being taught), by increasing the play field we may end up having results that do not match the users accurately. This is because users may get lost in a high number of choices. Consequently, they may get frustrated, irritated and lose their interest to the game. If this happens then the existence of the game as a "pleasant" initialisation way becomes pointless. Thus, we have to select an optimum number of pairs which will be able to give us the data we need while at the same time it will ensure that the game is pleasant for the users.

For this purpose we have selected the number of 15 pairs, meaning 30 tiles in a 6 by 5 matrix. When the game starts the matrix is filled randomly with the various images. Each time the positioning is completely different from the previous one. We start monitoring from the beginning up to and including the 11the pair. From then on we store the results of 12th and 13th for comparison and experimentation reasons and we discard the rest due to the very high "being lucky" probability.

The information that the application gathers during the play of the game is timestamps that have to do with the exact time each tile is flipped and whether the flip resulted to a successful pair match or not. Ebbinghaus mathematical model depends greatly on the time passed between seeing an item and using an item, thus we acquire these data from the user interface and then feed them to the model. The model then produces a retention percentage. This percentage shows the chance that the user has to actually remember the tiles he flips. The closer to 100% the percentage is, the higher the possibility of the gamer to remember the tile he chooses.

The mathematical model also depends on various factors that have to do with the gamer, e.g. the Base Retention Factor and Memorisation Ability (Manos & Virvou 2003). The aim of the application is to calculate these factors so that the model will be able to simulate the gamer' s responses. Whenever the model "predicts" falsely (e.g. the model says that the gamer knows where the tile is while the gamer chooses incorrectly and vice versa), these factors are being recalculated to fit the new information. After a number of times that the game has been played, the model can "predict" correctly the choices at about 80% of the times.

3.2 Model Usage

The retention user model that is generated by this application is not used in the same application for any other reason but for being updated and synchronised with the user's actual retention capabilities (since these change through the course of time). The principal aim of the creation of the memory user models is for them to be used as initial memory user models by other applications that need to know of the user's retention capabilities. One such application is VR-INTEGATE (Virvou et al. 2002; Manos & Virvou 2003). VR-INTEGATE is an authoring tool that generates educational games. VR-INTEGATE imports and uses the initial user models generated by the mobile game "Two-of-a-kind" to test the effectiveness of the educational game that it produces. It supplies the user models to artificial agents which walk through the educational software (that it generates) measuring which things the actual user learns (remembers) and which s/he forgets after the end of the virtual lesson. An accurate user model concerning the user's retention capabilities is very useful for the dynamic planning of the lessons to be taught by the educational game to each individual student so that s/he can learn and consolidate the knowledge at his/her individual pace. Thus the memory game "Two-of-a-kind" serves as a way to initialise the individual user models concerning the memory abilities of each user. Specifically, users may be asked to play the memory game at their leisure, at any time and any place where they have some spare time. As a result their memory user model is initialised.

Conclusions

In this paper, we have shown how a pleasant memory-game application may be used as a way of initialising individual user models concerning memory retention capabilities of users. The advantages of this method is that users do not have to fill in cumbersome questionnaires and the user modelling procedure does not have to depend on the users' beliefs about themselves, which may be inaccurate. Moreover, users do not have to devote time from their work which can be counterproductive but rather they can use the memory-game at their leisure time, anywhere they wish since the application is portable and can run both on desktop and mobile devices. The initialised user models may then be imported to another adaptive application that needs to have a model of users' retention capabilities. Such applications can be Intelligent Tutoring Systems that need to have a representation of the students' way of learning, how fast they memorise new syllabus etc.

References

Ebbinghaus, H. (1998) "Classics in Psychology, 1885: Vol. 20, Memory", R.H. Wozniak (Ed.), Thoemmes Press, 1998

McCalla, G. (1992) "The central importance of student modelling to intelligent tutoring". In E. Costa (Ed.) *New Directions for Intelligent Tutoring Systems*, Berlin: Springer Verlag.

Manos, K. & Virvou, M. (2003) "Memory Features in Simulated Students to Improve the Software Engineering Process and the Performance of Intelligent Tutoring Systems" In *Technology, Instruction, Cognition & Learning,* Vol. 1, No 4, pp.303-322, OCP Science Journals.

Sison, R. & Shimura, M. (1998) "Student Modeling and Machine Learning"**.** *International Journal of Artificial Intelligence in Education,* 9, 128-158.

Virvou, M., Manos, K., Katsionis, G. &Tourtoglou, K. (2002) "Incorporating the Culture of Virtual Reality Games into Educational Software via an Authoring Tool" *IEEE International Conference on Systems Man and Cybernetics 2002 (SMC 02),* Hammamet, Tunisia, October 2002, Vol. 2, pp. 326-331.