# Mouse Movement Monitoring in learning style detection

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## 1 Adaptive Hypermedia

During the last fifteen years many efforts have been made in order to build web-applications that are able to adapt. During the interaction of an user with the application, the behaviour changes in approaching him (or her) in the best possible way. Which is the meaning of best? It depends on the context. The user spends more money in a shopping site because he/she finds what he/she is looking for faster and also more than he was searching for. The user also learns better in an e-learning site, because the contents are exposed in the best way for him/her, etc.

## 2 User classification

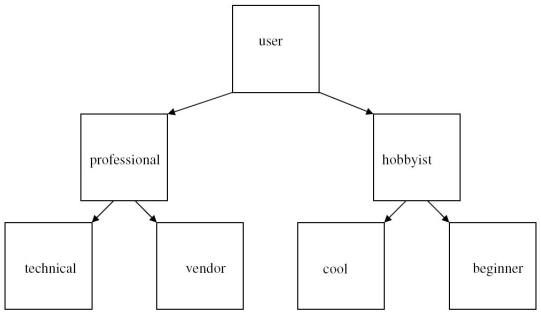
To obtain an adaptive web site, it is important to know the different types of users that will probably use it; in other words it is very important to detect peculiarities of different users in order to manage the behaviours and the contents of the application for them.

For example, if we wanted to build a web site that explains how to find or build components for High Fidelity Home Systems, it would be reasonable to imagine that both professionals and hobbyists will visit it. And we could subdivide these two categories. We could differentiate professionals with more technical skills from the vendors and the hobbyists with advanced building experience from the beginners

When we detect which user classes the web application will work with, it is possible to decide what[1] and how[2] to adapt.

[1] Behaviour and contents presented, for example

[2] Using intelligent modules or rules implementation for example




Sometimes it is very important to modify the approach of the application for the user during the interaction itself. Take this scenario as an example: Bob is a vendor who works in a music components shop and finds the web address of our adaptive site in a sticker on a client's walkman, so he decides to visit it.

Hopefully our web site begins adapting his behaviour to Bob's profile (professional-vendor) the first time he visits it. And Bob is very happy to find what he is interested in and also presented just the way that he prefers! He finds many interesting technical articles and passionately decides to start building his own components.

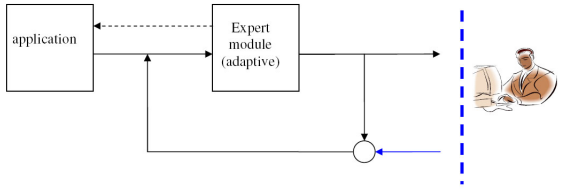
In few months he would be happier if our site adapted to his different side: the hobbyist-beginner. And when his passion grows and his experience increases the site would deal with him as a hobbyist-cool user.

Anyway during the week, due to his work, Bob continues using some information that is better ordered and structured for the professional-vendor profile.

In the end, the important thing for Bob is that our web site is really adaptive! If the application detected the profile only the first time the user visits it, the user would not take advantage

of other possible adaptations for his/her different capabilities and interests.

In this scenario, a possible approach would be to detect the user-profile during interaction, in a retroaction system approach where the system continually monitors the user's actions and reacts consequently:




*A gold rule of the world of retroaction systems is that the retroaction measurement instrument has to be as exact as possible in order for the system to work well and react properly. Furthermore any error introduced in the retroaction is amplified in the loop*

## 3 Learning style

There are many studies ([1], [2], [4]) that confirm that different persons have different attitudes about learning, and we all have the experience of learning easier a subject than other or having more difficulty with the same subject with a different approach or a with different instructor. There are also important researches that demonstrate the existence of different kinds of intelligence ([10], [11], [12]). In an adaptive e-learning application, a possible and very useful user classification would be one related to the user's learning style.

## 4 Felder-Silverman model and Index of Learning Style Questionnaire

In the field of learning styles, the reference model is the one of Felder-Silverman. It was exposed for the first time in 1988 [1] and, even though it has been slightly modified, it is still today a very important user classification instrument for learning styles. In the well known Felder-Silverman model there are four dimensions for the learning style:

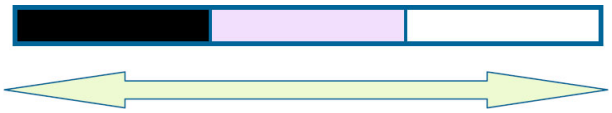
SENSING/INTUITIVE

VISUAL/VERBAL

ACTIVE/REFLECTIVE

SEQUENTIAL/GLOBAL

For each dimension, a learner can fit in one side or the other or be in the middle zone:



In this sense, there are 81 ($3^4$) different possible classes of learners. But, how to detect the class one fits in? A very famous web-based instrument is the Index of Learning Styles Questionnaire (ILS): it is a 44 question test that can help to assess the preferences of a user. The knowledge of the ILS of the students can help the instructor build a new course and suggest him/her the better way to expose the different units of a subject. Of course, the same information can be used to project an adaptive course for an adaptive hypermedia system.

## 5 Considerations

As we have seen, the objective of an adaptive Hypermedia system is to adapt contents and presentation to each class of user. In other words, the system must know the type of user and it would be even better if the system could continuously control the user's interaction to detect his/her current preferences (and consequently, the type). To define the different types of users it is important to find characteristics of interest in respect to the context in examination, like previous knowledge, attention level, experience with technologies, etc.

In an adaptive hypermedia e-learning system, a good trait of interest is the learning style, for example like in the Felder-Silverman model. When the class of a user is known, in terms of his/her learning style, the system can behave properly. But how is it possible to detect the learning style of an

user? To the date, the Index of Learning Styles Questionnaire is the most used instrument. The user, in the beginning of his/her interaction with an adaptive hypermedia system that uses learning styles for defining user's profiles, completes the test. This way the system can adapt his future behaviour depending on the results.

But this last step has some natural weak points:

- from the point of view of the accessibility for example, because the questionnaire takes time and doesn't exist in every language [3];
- the attention of the user could not be sufficient, jeopardizing the results of the test, and so, the entire process of adaptation;

And what would happen if the learning style of a user changes in different sessions, for example in exploring different subjects or during the evolution of his/her life and skills?

# 6 Objectives

We trust in the necessity of continuously monitoring the user for determining and controlling the current profile of the user during the interaction with an Adaptive Hypermedia system. Monitoring, for example, the steps he/she takes, the links he/she visits, the movements of the mouse, everything could help in reaching this goal. In the present work we concentrate principally in monitoring mouse movements: our interest is in a possible correlation between the way a user moves the mouse while interacting with a particular web-application and the 81 classes of the Felder-Silverman model. If this correlation existed, it would be possible to help the process of adaptability and, probably, to avoid the initial test stage in many cases.

# 7 Correlated works

In the Biometric field, there are studies that try to identify users on the basis of mouse-movement. There are researches that use the dynamics of the mouse based signature to give or deny access to an application [9], and there is another research that obtains an on-line re-authentication to reduce the susceptibility of a system to insider attacks. In this case the authors try to model the user behaviour, on the basis of mouse-movement, to continually monitor the session and flag anomalous behaviours [5]. These researches use state of the art pattern processing algorithms combined with artificial intelligence. In particular, the latter uses a supervised learning method to discriminate users. Another research of interest, mostly in relation to the used algorithms, is the one that tries to determinate a typical itinerary of an user's mobile to detect a possible theft ([6]).

To the date, there are adaptive hypermedia e-learning systems that register the user's step to find and define the class they belong to, most of all according to the current knowledge (monitoring for example the visited units, the solved exercises, etc.). Moreover there are well known adaptive systems (like Amazon and eBay) that use audit logs and program execution traces to adapt the contents proposed in accordance to the current user's preferences.

In this paper we present the idea of modelling the mouse-movement behaviour of users to put them in a learning style class of the Felder-Silverman model. To our knowledge our work is the first to present a possible correlation between a biometric behaviour and the learning styles.

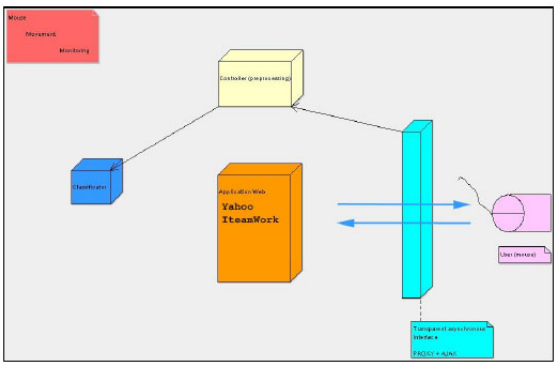
# 8 Architecture design

We made use of a simple architecture to obtain data on mouse movement, that includes a transparent interface between the user and the test application. This interface asynchronously collects and sends data, on the basis of user-invoked mouse movements, during the user's interaction. We principally used the Ajax technique to implement the asynchronously behaviour and the java servlets to collect and pre-process the data.

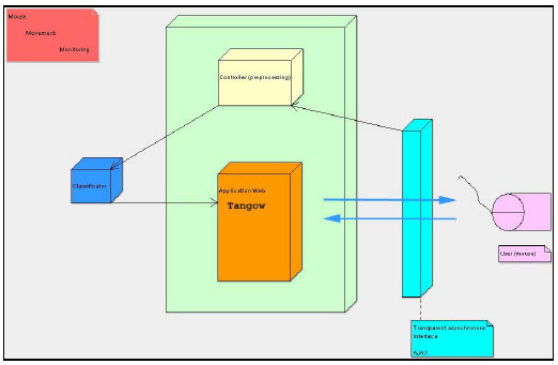
During the first tests we added the Ajax code directly to the HTML pages of third part applications (in the head section). To obtain this, we customized a filter of a proxy (an Open Source Proxy Server written in Java, called PAW) using regular expressions. Each page visited is modified with the addition of Ajax code. During the interaction, our Ajax code collects[3] the data and sends it to the con-

[3]The data are buffered it in an "appropriate" size array to optimize the behaviour

troller module, in this case running on a different application[4] .




We collected data of different users during sessions with fixed tasks in web sites like yahoo (email) and Iteamwork (building Gantt diagrams).




The permanent integration of this behaviour to any application would be obtained simply by adding the Ajax code directly to the head section of each page and integrating the processing servlets to the application[5].

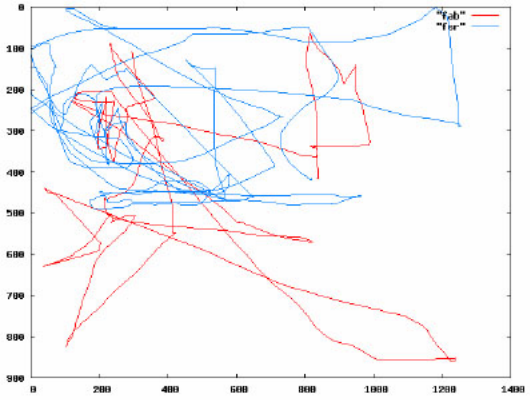
# 9 Simulation

We present the graphics of our last simulations. The experiment was implemented with two voluntaries browsing the yahoo web site (the email service) using the same computer and the same mouse device.

The tasks during the interaction were fixed a priori and structured this way:

1. login
2. overview
3. read email
4. write email
5. logout

These are the obtained trajectories, plotted in two colours:




You may notice that in this case, a more intuitive user has a more rounded behaviour than the more sensing user and that a more global user moves more around the hot zones than a more sequential user. Our underlying hypothesis is that it is possible to model a correlation between the user's learning styles and mouse movements, at least for a subgroup of dimensions of the Felder-Silverman model.

In a second step the same voluntaries completed the Index of Learning Style Questionnaire obtaining these results:

# 10 Conclusions & Future work

At the date we need more data to prove our hypothesis: the existence of a correlation between the mouse movement behaviour and the 81 (or minus)

[4]Due to the browser's security mechanism, known as "sandbox", these first experiences needed the settings of appropriate rights within the browser.

[5]In this case the Proxy would be removed from the architecture

| ILS fab fer | | |
|---|---|---|
| SENSING<br>fab | | INTUITIVE<br>fer |
| VISUAL | <br>fab | VERBAL<br>fer |
| ACTIVE | <br>fer | REFLECTIVE<br>fab |
| SEQUENTIAL | <br>fab | GLOBAL<br>fer |

classes of the Felder-Silverman model. Our future work will be to integrate the monitoring module in a real adaptive hypermedia e-learning system like Tangow to collect data in a real environment where the different classes of users are known in advance. An important task will be the data processing and the pattern extraction. Our principal aim is to improve the Tangow system and all the other applications that could take advantage of the information about the user's learning style to adapt their behaviour. Moreover it would be interesting to confirm if the learning style of a user can change when the subject changes or when the current task changes.

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