Clustering the Affective Aspects of Web Users

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ABSTRACT
Our objective was to study the effect of various design factors of web museums on judgments of user satisfaction; in particular satisfaction from aesthetics, interaction, finding the required information, etc. To this end we conducted a series of experiments with 47 persons in two countries who visited 23 web museums and subsequently recorded their experiences by asking them to fill out a questionnaire. We subsequently analysed the results of the questionnaire by applying a clustering technique to obtain meaningful groupings of web site usability vis a vis to user satisfaction. We also initiate a discussion of utilizing the results to create adaptive web sites to cope with the preferences and requirements of multiple user groups.

Categories and Subject Descriptors

H.5.4 [**Information Systems]:** Hypertext/Hypermedia --- Navigation, *User issues, Navigation.*

H.5.2. [**Information Systems**]: Interfaces and Presentation --- *User-centered design.*

General Terms
Design, Experimentation, Human Factors.

Keywords
Emotion, usability, clustering, affective responses, satisfaction, web sites, adaptive interfaces.

1. INTRODUCTION
Emotion is recognized as one of the most powerful aspects in a user's experience of the web, because of its influence on one's perception and navigation of websites [4], [12]. For example, a "well-organized," "functional" and "appealing" website influences one's feeling of trust, perception of security and usability, and sense of credibility [5] [8] [16]

Our interest here is to examine a user's *emotional responses*—in particular, *satisfaction* or *dissatisfaction*—associated with web design. *Satisfaction* refers to a user's emotional response to a particular web design and is a function of the *perceived* relationship between what one wants from a web site and what one *perceives* it is offering to a user. In other words, it involves a user's *perceptions* of a website—e.g. his or her mental effort, attention distribution, cognitive overload—and a user's *emotional responses*, as a result of these perceptions—e.g. his or her positive or negative experience (i.e. satisfaction or dissatisfaction) from interacting with a website; to what extent the user feels able to influence the interaction experience (feeling of control); and, who is perceived to be at blame for positive/negative experiences from interacting with the web site. Such emotional responses are primarily rooted in evaluations of *appealingness*—momentary reactions of liking or disliking [13]. Satisfaction or dissatisfaction thus derives from how a user perceives the characteristics of a website as well as what emotional reactions these characteristics create to the user.

The purpose of this paper is to investigate the relationship between usability and user satisfaction in Web Museums. Web museums are web sites of a particular nature and thus have specific goals they have to meet in terms of their visitors' experience. Therefore, it is interesting to examine the clustering of affective aspects of visitors in Web Museums.

2. THEORETICAL BACKGROUND
Emotion is nowadays considered to play a critical role in design and usability, as aesthetic and other affective aspects of design and usability become major competitive factors in the market economy [6] [7] [9] [10] [11]. Emotion is inextricable to a user's motivations, emotions and expectations, as one explores a web site in order to achieve a desired cognitive and emotional outcome. The importance of a user's perceptions in navigating the web is also supported by Bandura's [1][2] key ideas which emphasize that self-efficacy beliefs are critical factors of how well knowledge and skill are acquired.

Emotions are essentially an individual's *evaluations* of events, objects and people [13] [17]. Our claims about the structure of particular emotions (e.g. anxiety, frustration, enjoyment etc.) is that *if* an individual *perceives* a situation in a certain way, *then* the potential for a particular emotion arises (without assuming that the opposite does not happen, i.e. it is also true that an emotional response colours one's perceptions of an event, see [13]. We do not attempt to specify the mechanisms that determine this process; this is a more general and complex problem for cognitive sciences and it is not specific to the study of emotions. Our goal in this project is to contribute to an exploration of affective factors in web design through the development of a computational model of emotion (similar efforts have been going on for some time in the field of artificial intelligence and affective computing; see, e.g. [15].

Generally, emotion computing involves techniques from signal processing for capturing facial features or the intonation of voice and then inferences about the underlying emotional states. Techniques beyond human perception have also been used, such as an infrared thermogram.

In the current study, we have considered a much simpler way of capturing emotions: we have constructed a questionnaire (see Table 1). The questionnaire we have designed involves both perceptual and emotional aspects related to virtual visits in museums. The questionnaire is filled up upon the completion of the visit and involves questions about objective observations of elements of the web site; the responses to these questions represent the user's *perceptions*. The questionnaire also includes questions that elicit subjective responses; these responses provide indications for the user's *emotions*. Based on the theoretical framework we have described earlier, we distinguish between *perceptions* and *emotions* because we wish to discover the relationship between particular perceptions and particular emotions. We have distinguished questions (see Table 1) that refer to perceptual end emotional elements of a web site according to the following table:

Table 1. Perception versus Emotion Questions

Perception, related questions	**Emotion, related questions**
Questions a-f, 1-26	Questions 27-31

3. EXPERIMENTAL SETTING

The total number of individuals who participated was: 28 postgraduate students of computer science (15 males and 13 females) from the University of Piraeus, Greece and 19 undergraduate students from the University of Cyprus, in Nicosia, Cyprus (13 males and 6 females). Both groups were asked to complete a questionnaire after they had visited a predefined list of museums. The Greek group provided 83 sessions whereas the Cypriot one 78. After the end of each session (one user may have visited more than one museums) a online questionnaire of 37 questions was completed (see Table 2). The results are located at http://cosy.ted.unipi.gr/survey3/. All participants were well aware of usability issues of interactive systems, since they had already attended an advanced course on Human Computer Interaction.. Finally, participants had also experience in working in groups; therefore, it was not difficult to form groups of participants for the synergetic task of the evaluation study.

3.1 Task

Taking part in the study of user experience of web museums, participants had to put individual as well as collective effort. Each participant had to choose three (3) out of 23 candidate museums (archaeological, maritime, art, etc.) without previously accessing their web site. We wanted to ensure that each participant had no prior idea of the quality of the web museum.

The participants were subsequently asked to assume that they wanted to physically visit the particular museums and for that purpose they needed to find out:

• Where the museums are located (i.e. their addresses),

• Opening times,

• Permanent exhibitions,

• Current exhibitions, and

• Whether they could get a tour, and how (e.g. contact number)

Moreover, they were asked to browse through the website to identify sections that would interest them the most, as well as to get an idea of the museums' collections and items. Participants had been encouraged to use the search facility to quickly find what they wanted, as well as to keep notes for the things that they liked or disliked. The aforementioned tasks aimed to cover the basic and most important functions that web museums have to offer their visitors.

Table 2. Extract from the questionnaire given to subjects

I. General questions
(Answer List: Yes, it was easy; Yes, but it was difficult; I found something, but I am not sure that's it; No, and I am sure it is not avail-able)
a. Were you able to find the museum's address? b. Were you able to find the days/times it is open? c. Were you able to identify the museum's permanent exhibition/ collection? d. Were you able to identify the museum's current exhibition? e. Were you able to find out whether you can get a tour and how? f. Was there a search facility?
II. Specific questions (Answer List: Strongly Disagree; Disagree; Neutral; Agree; Strongly Agree)
1. I felt that the colours used on this website were not appropriate. 2. The colours used were distracting. 3. The colours used seemed to be related to the theme of the museum. 4. This website lacked colour. 5. The colours used were depressing. 6. This website was very suitable for a web museum. 7. My first impression from this website was that it was very complex. 8. Important information was very difficult (or impossible) to locate. 9. Information on the website was organized in a very logical way. 10. I found it easy to follow the various links and acquire the information I needed. 11. Images on the website were too big in size and took a long time to download. 12. Images were too small to see the artefact properly. 13. The image quality was excellent. 14. There were not enough images on the website to give a good idea of the museum's collection. 15. I think that images are the most important feature of a web museum. 16. I particularly liked the animated images that were included in the website

17. The website had virtual tours of the rooms of the museum. 18. I did not like virtual tours. 19. I enjoyed the additional features that were available on this website. 20. This website was also educational. 21. I learnt so many things from the website that I do not need to visit the museum itself. 22. The website made a bad impression on me and so I changed my mind about visiting it. 23. It was so interesting that I spent more time than I thought I would. 24. Overall, this was a very good website. 25. This website was dull 26. I would visit this website again to find out what's new.
III. Satisfaction Questions: (Answer List: Highly Dissatisfying; Dissatisfying; Neutral; Satisfying; Highly Satisfying)
27. How satisfying did you find the aesthetic design of this web museum? 28. How satisfying did you find the features/ functions offered in this web museum? 29. How satisfying did you find your interaction with this website? 30. How satisfying did you find your capacity to gather the information you needed from this website? 31. How satisfying did you find the amount of mental effort required to navigate through the web museum?

4. CLUSTERING

The total number of sessions (for both groups) created a data set of 161 samples. We were interested in analyzing the interplay of web design factors and various forms of user satisfaction (questions 27-31) in the domain of web museums. Thus we discarded the first 6 questions of the questionnaire. The next step was to convert the answers to the remaining 31 questions into numerical values. The coding we followed is as follows: strongly disagree→1, disagree→2, neutral→3, agree→4, strongly agree→5 and we obtained a data set of 161 vectors of 31 dimensions (attributes). At this point the issue was to discover interesting groupings of answers in the questionnaire. For this purpose, we have employed a widely used clustering method, the k-means, which requires predetermining the number of clusters into which the data vectors will be classified (see [4] for an overview of clustering algorithms and cluster evaluation methods). The idea was to discover emotional and perceptual features that affect the overall usability evaluation. We have employed the Davies Bouldin (DB) index to discover the optimum number of clusters. The DB index is defined as follows:

$$DB = \frac{1}{K}\sum_{j=1}^{K}\max(R_{i,j}),\ for\ all\ i \in [1,K],\ i \neq j$$

Where K is the number of clusters and

$$R_{i,j} = \frac{s_i + s_j}{d_{i,j}}$$

and

$$s_i = \sqrt{\frac{1}{card(K_i)}\sum_{x \in K_i}\left\|x - z_i\right\|^2}$$

And

$$d_{i,j} = \max\left\|z_i - z_j\right\|, \quad i \geq 1,\ j \leq K$$

where z_i is the centroid of cluster K_i and x is a datum. The DB index is an expression of the notion that each clusters' data should be similar and dissimilar to data that belong to other clusters. The DB index is calculated for various K (number of clusters) the minimum value corresponds to the optimal cluster size. The optimum number of clusters was 16 for the 161 samples of 31 attributes each (see also Figure 1), the results reported are averages over 50 experiments.

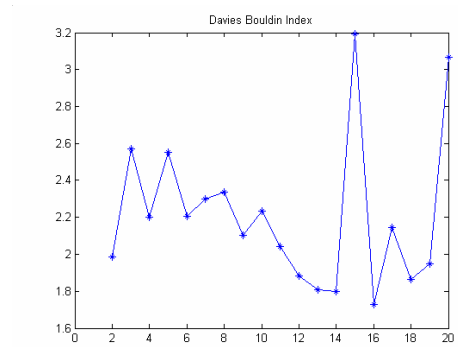

Figure 1. Davies Bouldin Index for 2-20 Clusters, Best Value at 16

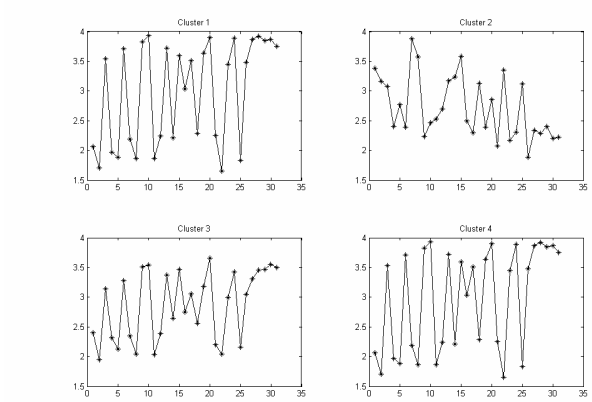

Figure 2. All Attribute Values for Selected Clusters

Subsequently, for each cluster we preserved the attributes that had low variance (i.e. those that tended not to be very much dispersed), which means that preserved variables tend to correspond to values such as either *agree* or *neutral* or *disagree.* Attributes that assume all values are not considered good for cluster description. The results we obtained are summarized in Table 3 and Table 4. Also we disregarded clusters that are characterized by a single attribute, or where the variance of all attributes is high, thus we ended up with 4 clusters; their values

are depicted in Figure 2. In all experiments we have used MatLab (http://www.mathworks.com/ V6.5) with the SOM toolbox (http://www.cis.hut.fi/projects/somtoolbox/).

Table 3. Clusters

Cluster #	Attributes denoted by numbers and attribute values (ll=low, h=high)
1	2(l) 14(l) 22(l) 24(h) 27(h) 28(h) 30(h)
2	20(h) 24(h) 29(h)
3	2(l) 7(l) 8(l) 10(h) 19(h) 24(h) 25(l) 28(h) 29(h)
4	13(h) 23(l) 28(l)

Table 4. Lingustic Interpretation of Clusters

Cluster #	Linguistic Interpretation
1	• *Disagree:* The colours used were distracting • *Disagree:*There were not enough images on the website to give a good idea of the museum's collection. • *Disagree:*The website made a bad impression on me and so I changed my mind about visiting it • *Agree*: Overall, this was a very good website • *Satisfying* How satisfying did you find the aesthetic design of this web museum? • *Satisfying:* How satisfying did you find the features/ functions offered in this web museum? • *Satisfying:* How satisfying did you find your capacity to gather the information you needed from this website?
2	• *Agree*: This website was also educational. • *Agree*: Overall, this was a very good website. • *Satisfying:*How satisfying did you find your interaction with this website?
3	• *Disagree:*The colours used were distracting. • *Disagree*: My first impression from this website was that it was very complex. • *Disagree:* Important information was very difficult (or impossible) to locate. • *Agree:* I found it easy to follow the various links and acquire the information I needed. • *Agree:* I enjoyed the additional features that were available on this website. • *Agree:* Overall, this was a very good website. • *Disagree*: This website was dull • *Satisfying:* How satisfying did you find the features/ functions offered in this web museum? • *Satisfying: How satisfying did you find your interaction with this website?*
4	• *Agree:* The image quality was excellent. • *Disagree:* It was so interesting that I spent more time than I thought I would. • *Dissatisfying:* How satisfying did you find the features/ functions offered in this web museum?

The first cluster contains users that were satisfied from the aesthetics, the features and the capacity to gather information; the second one contains users that were satisfied from the interaction with the web site. The third cluster includes users that were satisfied with the interaction but also with the features. Finally, the last cluster is about users that were not satisfied with the features that were offered by the web museum. The first cluster seems reasonable; however the second looks at a first glance spurious: the users who found some web sites as educational seem also to consider them also as being equipped with good interaction. Also the third cluster is a description of reasonable facts: easy to navigate coincides with satisfaction from interaction; and enjoying the additional features leads to satisfaction from features. The fourth cluster is somehow cryptic: users who did not find the site interesting, were not satisfied by the features/functions.

5. ADAPTATION

When designing museum websites it is important to recognize typical users. The audience of a web museum covers a wide range and may include the following types of users:

- **Users who plan to visit the physical museum**. These users need information about what is currently exhibited at the museum, as well as basic information such as opening hours, ticket sales and route descriptions. Furthermore, it is highly probable that they will want to identify objects they will want to see.

- **Users who have visited the museum in the past**. These users may want to look up some additional information on particular objects they saw and maybe make some purchases.

- **Educators and Researchers**. Educators will probably need more specific information about particular objects, such as historical context, research on the object, etc.

- **Curators**. Curators usually need very detailed information about every single item of the collection including information acquisition, restoration, preservation, dimensions, and so on.

- **Children**. Children are a very different category of users. They would want to play and learn at the same time.

- **Potential visitors who are not able to visit the physical museum**. Users that live far from the physical museum or users that are physically not able to go to the museum will want to get an experience similar to the real one.

- **Managers and donators**. These users have a general interest in the museum.

The intention of any website is to offer the best possible experience and possibly also guide the users towards a target, which may be increasing sales in the e-commerce domain or visiting certain thematic pages in a web museum. If the user feels frustrated by the site's structure, (s)he is disappointed by the presentation of the exhibits or (s)he is not motivated to explore

the site, (s)he will end up wasting time and it is likely that (s)he will never return. Thus the site fails the purpose for which it has been designed. Furthermore, as previously mentioned, different users have different needs, desires. Someone may be interested in looking at the detailed information; another one may not have the time for anything more than a brief overview of the main exhibits and so on.

The solution is to adapt the website (dynamically or not) to the particular user (or user category) and ultimately offer an optimal experience, with positive emotional responses. Adaptation can be seen as changing the navigation model, the presentation of material (e.g. colours, image quality) and the structure of the material (e.g. detailed information, scarce information). Information about the user, which will refer to both affective and non-affective issues, will be used to determine the most suitable website features and type of interaction that should be offered. For example, likeness of colours of the site, or dullness created by the exhibits can be great promoters/inhibitors for the site's exploration. Non-affective issues concern the size of downloadable information about exhibits, the amount of navigation that is necessary to reach the required information.

The clusters that have been proposed in this paper can be used for the purpose of adaptation: each user will be matched against the clusters available revealing the most suitable one, which will determine the website features and type of interaction that should be offered to the particular user to lead to positive emotional responses. Clusters will include information regarding preferences, likes/dislikes, needs, etc. related to web museum interaction. Since clusters essentially play the role of user groups/categories, it is foreseen that clusters will be dynamically updated, maintaining an accurate picture of web museum users.

6. CONCLUSION

We have conducted a study with the objective of relating various aspects of web site design with five different views of user satisfaction. The results that we processed are in the form of questionnaires that were completed by users after visiting some web museums from a designated list. Cluster analysis and characterization enabled us to derive some early results. The next step is to enrich our experiment with more users enabling us to obtain more reliable clustering. Second the derived clusters will allow us to revise the questionnaire, so as to remove trivial conclusions about users belonging in the same cluster. Also, new questions could help up formulate a detailed view of users' interests when visiting web museums (for instance is s/he a casual visitor/ student writing a report?).

As part of future work, we will aim for a general framework for adaptation of a web museum to the user's preferences, habits, likes/dislikes. It is based on some principles: the existence of a relatively large number of historical data, about users, the pages they visited, the time spent on each page, the terms they have searched in the web museum's search engine and finally whether they have accomplished the web museum's target, which might be to go through specific pages: where the permanent collection is exhibited, to discover a special exhibition, etc.

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