Rate, Recommend, Regret – an Expert-based Approach to the Personalization of Guided Tours

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Abstract. In this paper we propose an approach to generate personalized guided tours based on a finite collection of tours obtained by tracking the navigation of expert users. Our proposal is based on a variant of decision theory, that uses a regret function to measure the difference between a proposed decision and a finite collection of expert decisions, generalized to a finite sequence of discrete choices. Personalization may then be seen as a minimization problem over a weighting scheme, expressing the relative importance of experts of which tours are available. We illustrate our approach by showing how we may obtain guided tours in 3D digital dossiers containing information on contemporary art installations, and discuss how our approach may be applied in other cultural heritage applications.
keywords: decision theory, personalization, guided tours, digital dossier, cultural heritage

1 Introduction

Leaving all responsibility for interaction to the user is usually not a good choice, in particular when an information system contains complex, highly interrelated information. In Eliens et al. (2006b), Wang et al. (2006), van Riel et al. (2006) we describe the *3D digital dossier* format, in which we presented the information of respectively the Dutch-Serbian artist Marina Abramovic[3] and the Australian artist Jeffrey Shaw[4], contemporary artists with a variety of work, ranging from video to art installations. The *digital dossier* supports navigation using a concept graph and allows for presenting media-rich material, including 3D models of artwork installations. The digital dossiers have been implemented using X3D/VRML[5] to allow for deployment on the web.

Recently we have explored *guided tours* in digital dossiers, van Riel et al. (2006), which actually automate user interaction, by mimicking user actions

[3] www.few.vu.nl/∼dossier05
[4] www.few.vu.nl/∼casus05
[5] www.web3d.org

through events generated by a script. Although this provides an easy way to create guided tours, this does not solve the problem of what to select as elements in the guided tour, or how to personalize these tours in an intelligent manner.

In this paper, we discuss techniques from decision theory as a means to aid the construction of guided tours by consulting an advice function based on tracking the navigation behavior of expert users. We will also indicate how a similar advice function can be used for personalizing tours in cooperation with a recommender system for artworks, by altering the weight given to particular properties.

structure The structure of this paper is as follows. In section 2 we will briefly describe the *abramovic* dossier. In section 3 we will give a brief introduction to decision theory, and in sections 4 and 5 we will discuss how techniques from decision theory can be applied to the construction of guided tours in digital dossiers by using expert advice. In section 6, we will illustrate how to apply decision theory for the personalization of tours in a more conventional cultural heritage application and in section 7 we will discuss how to realize expert advice functions in digital dossiers. Finally, in section 8 we will give our conclusions and indicate directions for future research.

2 The *abramovic* dossier

As a user interface for navigating the *abramovic* dossier, we created a concept graph, fig. 1(a), that represents arbitrary information structures in a hierarchical way. The concept graph allows the user to detect relations and search for information. Unlike the 3D cone tree, Robertson and MacKinlay (1991), where the complete hierarchical structure is presented, only a subset of the hierarchy is shown - three levels deep.

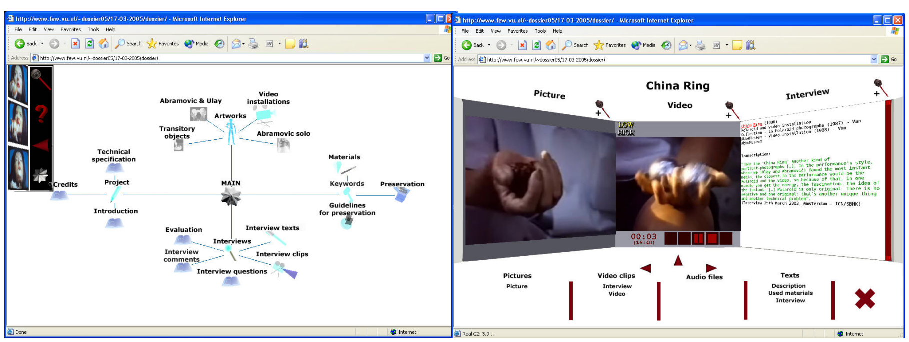

Fig. 1(a) Concept Graph (b) Presentation gadget

Presentation is an essential part of the digital dossier but is separated from navigation. The digital dossier contains different presentation facilities for 2D and 3D content. For 2D media content we need to be able to present video, images or textual information. This is implemented as a presentation gadget with three windows, fig 1(b). In each of the three windows the user can view either text, image or video content. The windows are positioned in such a way that the user can inspect the information simultaneously. In our experience, three views can be presented at the same time without much visual distortion.

usage scenario: When starting the dossier, it loads the concept graph that is used to navigate through the available information. In the center of the concept graph, a shining star is shown to illustrate the root of the information hierarchy, which is used as the start object. When clicked, a star structure spreads and child objects appear surrounding the center star object.

Clicking on the *Interviews* node gives an overview of all interview fragments, then going back clicking on the information node *Artworks* and then on *China Ring* will bring the node for *China Ring* into focus. When clicking on the center node *China Ring*, a content presentation environment appears. which has three windows to present different types of information, grouped into the categories text, pictures and video. If desired, the user can focus on any window by using a zoom function. When the presentation of media content is finished, clicking on the close button will result in going back to the concept graph. Alternatively, the home function of the tool bar may be used to return directly to where we started: the original shining star.

3 Mathematical preliminaries – decision theory

Before discussing how to realize guided tours in digital dossiers using user tracking and expert advice, we will give a very brief introduction to decision theory, more in particular a variant of decsion theory introduced in Cesa-Bianchi and Lugosi (2006), that provides a mathematical foundation for our approach.

In classical prediction theory a prediction is a sequence of elements $x_1, x_2, \ldots$ that results from a stationary stochastic process. The risk of the prediction is taken to be the expected value of the accumulated *loss* function, measuring the discrepancy between predicted values and actual outcomes. Cesa-Bianchi and Lugosi (2006) introduce a variant of prediction theory in which no assumption is made with respect to the nature of the source of predictions. Instead, the *forecaster* is considered to be an entity that gives a prediction for an element based on *advice* of one or more *experts*. These experts might be actual sequences stored in a database. The deviation of the forecaster with the actual outcome is measured using a *regret* function, and the prediction task may hence be formulated as minimimizing the *regret* function by choosing the best expert for advice for each element of a prediction sequence.

For example, for the prediction of a bitstring of length n, the forecaster is a vector of n expert indices, that give advice for the bitvalue, *0* or *1*, in that position. In the general case, in which we have no information on the error rate of the experts' advice, we may use a weighting factor $0 \leqslant \beta_i \leqslant 1$ for each expert i, to indicate the credibility of the experts' advice. After each prediction, obtained by taking the majority decision of the experts, according to the weighting scheme, we may verify which experts fail to give the right advice, and decrease their weight, thus eliminating the influence of their advice in the long run.

4 Guided tours in digital dossiers

In digital dossiers, we explored the use of guided tours as a means to present the information in a story-like way, relieving the user of the often cumbersome task to interact, van Riel et al. (2006b). Guided tours, in the digital dossier, may take one of the following forms:

- automated (viewpoint) navigation in virtual space,
- an animation explaining, for example, the construction of an artwork, or
- the (narrative) presentation of a sequence of concept nodes.

In practice, a guided tour may be constructed as a combination of these elements, interweaving, for example, the explanation of concepts, or biographic material of the artist, with the demonstration of the positioning of an artwork in an exhibition space.

A pre-condition for the construction of guided tours based on user tracking is that navigation consists of a small number of discrete steps. This excludes the construction of arbitrary guided tours in virtual space, since it is not immediately obvious how navigation in virtual space may be properly discretized. In this case, as we will discuss in section 7, a guided tour may be constructed using a programmed agent showing the user around.

For navigation in the concept graph, as well as for the activation of the media presentation gadget, the discretization pre-condition holds, and a guided tour may be composed from a finite number of discrete steps, reflecting the choice of the user for a particular node or interaction with the presentation gadget.

For example, in the *abramovic* dossier, the user has the option to gode from the *Main* node to either *Artworks*, *Video Installations* or *Interviews*, and from there on further to any of the items under the chosen category. Tracking the actual sequences of choices of a user would suffice to create a guided tour, simply by re-playing all steps.

To obtain more interesting tours, we may track the navigation behavior of several experts for a particular task, for example retrieving information about the installation *Terra della dea Madre*. In case the experts disagree on a particular step in the tour, we may take the majority decision, and possibly correct this by adjusting the weight for one or more experts. When we have a database of tours from a number of experts, we may offer the user a choice of tours, and even allow to give priority to one or more of his/her favorite experts, again simply by adjusting the weighting scheme.

As a technical requirement, it must be possible to normalize interaction sequences, to eliminate the influence of short-cuts, and to allow for comparison between a collection of recordings. For the actual playback, as a guided tour, a decision mechanism is needed that finds the advice at each decision point, from each expert, to select the best step, according to a decision rule that takes the weighting scheme into account.

5 Personalization by expert rating

In a more mathematical way, we may state that for each node n we have a successor function $S(n)$, that lists the collection of nodes connected with n, which we may write as $S(n) = n_1, ..., n_k$, where the suffix $i \leq k$ is an arbitrary integer index over the successor nodes. To take a history of navigation into account, we let $\overline{p}$ be a string of integers, representing the choices made, encoding the navigation path. So, for a node $n_{\overline{p}}$, with history $\overline{p}$, the collection of successor nodes is $S_{\overline{p}}(n) = n_{\overline{p}1}, ..., n_{\overline{p}k}$. Now assume that we have a weight function w, that assigns to each expert e_i a weight $0 \leq \beta_i \leq 1$, indicating the relevance of expert i. Then for a particular node n we may assume to have an advice $\alpha_i = x$, with weight β_i and x in $S(n)$. If an expert has no advice for this node, we may simply assume its weight to be 0. For a collection of experts, the final advice will be $\alpha(n) = \alpha_i(n)$ with weight β_i and $w(e_i){>}w(e_j)$ for $i{\neq}j$. If no such advice $\alpha_i(n)$ exists, we may query the user to decide which expert has preference, and adapt the weights for the experts accordingly. This procedure can be easily generalized to nodes $n_{\overline{p}}$ with history $\overline{p}$. To cope with possible shortcuts, for example when a choice is made for a node at three levels deep, we must normalize the path, by inserting the intermediate node, in order to allow for comparison between experts. Now assume that we have expert navigation paths with cycles, for example $n_{\overline{p}} \rightarrow n_{\overline{p}1} \rightarrow n_{\overline{p}13}$, where actually $n_{\overline{p}} = n_{\overline{p}13}$, which happens when we return to the original node. In general such cycles should be eliminated, unless they can be regarded as an essential subtour. However, in this case, they could also be offered explicitly as a subtour, if they have length $\geqslant 4$.

When offering guided tours for which several variants exists, we may allow the user to simply assign weights to each of the experts from which we have a tour, or allow for incrementally adjusting the weight of the experts, as feedback on the actual tour presented.

6 Incremental adaptation of recommendations

In the CHIP[6] project (Cultural Heritage Information Personalization), the aim is to develop a recommender system that generates a collection of artworks in accordance with the users' preferences based on the rating of a small sample of artworks. The properties on which the recommendation is based include *Period*, *Artist*, and *Genre*. The recommender system will also be used to generate guided tours, where apart from the already mentioned properties the *Location* (the proximity in the actual museum) will be taken into account. Using a weighting scheme on the properties, that is a difference metric on the properties, a graph can be created, giving a prioritized accessibility relation between each artwork and a collection of related artworks. By changing the weight for one of the properties, for example *Location*, in case the tour is generated for the actual museum, the priority ordering may be changed, resulting in a different tour.

[6] www.chip-project.org

In contrast to the successor function for nodes in the concept graph of the digital dossier, we may assume to have a weighted successor function $S_w(n) = (n_1, \omega_1), \ldots, (n_k, \omega_k)$, with $\omega_i = w(n_i)$ the weight defined by the relevance of the node n_i, with respect to the attributes involved.

In a similar way as for the digital dossier, user tracking may be deployed to incrementally change the weight of the arcs of the graph, reflecting the actual preference of the user when deviating from an existing guided tour.

7 Intelligent guidance – realization

Our aim is to arrive at a general framework for artist's digital dossiers, that provide intelligent guidance to both the expert user, responsible for the future re-installation of the work(s), and the interested layman, that wishes to get acquainted with a particular work or collection of works. In general, there are two techniques that we can apply to provide such guidance:

- filtering the information space according to the user's perspective, and
- intelligent agents, that (pro) actively aid the user in searching the information space.

Filtering the information space may be used to restrict the concept graph that defines the navigation structure, by stating assumptions with respect to the relevance of particular categories from a user's perspective. Intelligent agents is an approach stemming from artificial intelligence which allows for providing guidance in a variety of ways, possibly even in an embodied form using a face or humanoid figure to give suggestions to the user on what interactions to perform, an approach that we will discuss later on. For selecting the items to be presented in a guided tour, the most obvious way is to pre-define a sequence based on user profiles. Very likely this can be done in a more flexible way in a rule-based manner, applied to a template tour. More interesting, however, is to generate guided tours dynamically based on tracking actual user interaction of (expert) users, using techniques from prediction theory, as explained in sections 4 and 5.

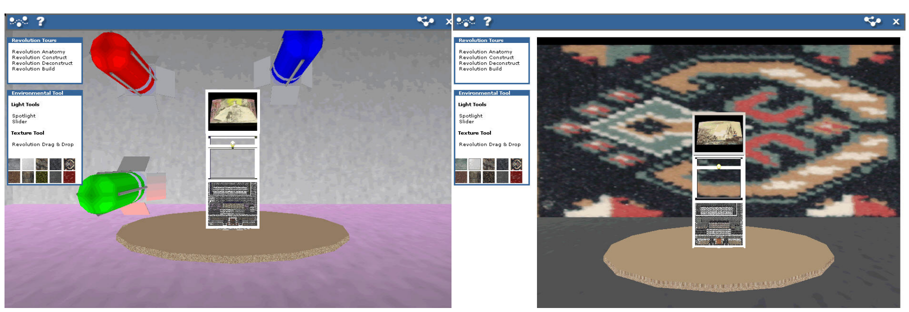

Fig. 2: (a) Light (b) Material

A special case of a guided tour is the tool environment constructed for the *Revolution* installation of Jeffrey Shaw, which allows for experimenting with the (de-) construction of the installation, fig. 2(a), and exhibition parameters, fig. 2(b).

Tracking interaction with such 3D models is, given the limitations imposed by the tool environment, relatively simple, and can be used for creating a repository of navigation sequences. More difficult, however, is to find proper normalizations for these interactions, and so in this case we may possibly have to rely on expert weighting only.

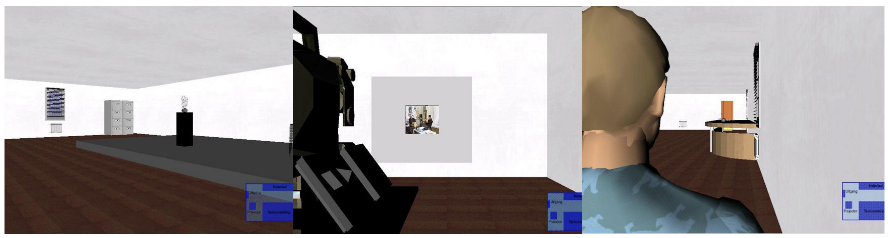

Fig. 3 (a) Overview (b) Interview (c) Agent

agent technology In [_Agents] we have investigated the use of embodied agents in a digital dossier for the artist Marinus Boezem, fig. 3. To allow for a discrete mode of navigation we have used a map, displaying the interesting parts of the atelier, which contains locations where relevant information can be obtained, such as a filmprojector, for displaying interviews, a cabinet that contains biographical material and textual descriptions of the artworks, and an exhibition environment that displays (3D models of the) artworks. To construct a guided tour, we deployed a humanoid agent that shows the user around.

In a user evaluation test we found that humanoid agents where instrumental in providing information about the re-installation of artworks, but interestingly also that believability was positively affected by the degree of realism of the agent, Van Vugt et al. (2006). However, in creating guided tours for the current generation of digital dossiers, using concept graphs for navigation instead of a spatial metaphor, we will not use humanoid agents. Our agent technology, however, can be used in a fruitful way. In the I-GUARD[7] project (Intelligent Guidance in Archives and Dossiers). we investigate how to realize *advice functions*, implemented using agent technology, Eliens et al. (2002), based on actual navigation paths obtained by tracking expert users, that offer the user at any navigation point a choice of continuations and/or a selection of guided tours, focussing on a topic of interest.

8 Conclusions

In this paper we have sketched an approach for the construction or adaptation of guided tours, using techniques from decision theory, in particular the application of a weighting scheme determining the outcome of an *advice* function, based on

[7] www.cs.vu.nl/∼eliens/i-guard.html

stored preferences of (expert) users. This technique may also be applied in an incremental fashion to adapt an existing tour to personal preferences, reflecting the actual navigation behavior of users. The application of these techniques requires that choices are discrete and hence do not apply to arbitrary navigation in virtual environments, unless we find proper ways to encode such navigation as a small finite collection of discrete steps. Also in the discrete case, however, we must be able to normalize navigation paths, in order to compare and weigh the contribution of a collection of experts.

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