Putting forecasting skills into Websites: personalized prevention of high risk events

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Abstract: - A formidable synergy can be obtained by putting expert systems technology into Websites. Websites should be able to infer hypotheses about the present and the future. Websites endowed with inference capabilities are able to provide users with advanced services that enhance their competitiveness. In particular, a Website able to hypothesize future situations may be useful in many important fields: e-marketing, e-recruitment, e-learning, etc. The paper presents a method for endowing Websites with forecasting skills based on Dynamic Bayesian Networks. In particular, the paper addresses the theme of the personalized prevention of high risk events.

Key-Words: - Embedded expert system, Dynamic Bayesian networks, Risk prevention, Value of information, Probabilistic reasoning, Adaptive Website

1 Introduction

In recent years great emphasis has been given to collaborative Websites (for short, in the following, sites), sites able to effectively help their users and create personalized relations with their users [1] [2] [3] [8]. The basic problem underlying this feature is that sites must be equipped with adequate general knowledge and able to infer specific knowledge about each specific user. In other words, sites must behave like knowledge-based inferential machines ("… only then can computers become truly concerned with our human affairs." [5]). Given that, the following questions arise: what kind of knowledge should be put into a site? What kind of reasoning should a site do? Of course the answers depend on the kind problem a site should solve in order to be collaborative. However in a great variety of real cases, the problem that a site has to cope with in order to be collaborative, can be classified as a diagnostic problem. For example, in the e-marketing field, user-needs are diagnosed on the basis of few user-profile data [6], in the e-recruitment field, particular bents to a given kind of job are diagnosed on the basis of the candidate-curriculum data, in the e-learning field, the specific student problem is diagnosed on the basis of student mistakes and behavior, etc.

Since, in general, real world situations change, sites, in order to be actually collaborative, should be able to reason not only on the real world in the present time but also on a hypothetical world in a future time. In other words, they should be able to hypothesize possible future situations. For example, in a one-to-one marketing site, it might happen that a piece of news may appear irrelevant today but turn out to be important in two months, when a certain user-need is supposed to be mature.

Finally, since the world is affected by uncertainty and uncertainty is pervasive, a site should be able to reason under uncertainty.

Given all the considerations so far made, a question arises: which tool should a site designer use to make his/her site able to reason under uncertainty about the present and the future? A very well known and widely used tool suitable for that is represented by Dynamic Bayesian Networks (DBN's) [7] [4]. The paper shows a method for designing a DBN-based site devoted to aid its users to prevent occurrences of high risk events in a personalized manner. The method is general and can be applied to a variety of heterogeneous fields where risk prevention is useful: medicine, very expensive electromechanical devices (e.g. high power transformers), finance, etc. The author believes that the general ideas presented in the paper may be useful to site designers aiming at getting competitive sites endowed with advanced features.

The paper is organized as follows. Section 2 presents the core model: the general DBN structure that underlies the proposal. Section 3 presents some general guide-lines for designing a site architecture based on the core model of section 2. Section 3 draws some conclusions.

2 Core model

Let us examine the structure of the model underlying the proposal by analyzing its two basic components: the causal structure and the temporal structure.

2.1 Causal structure

Let us view high risk events (HRE nodes) as possible effects of system anomalies (SA nodes). For example, in the medicine field, “ischaemic cardiopathy” (SA node) can be a cause of “cardiac infarct” (HRE node). In general, system anomalies also cause anomalous manifestations (AM nodes) (e.g. anomalous episodes, anomalous values of critical variables, etc.). Moreover, in real world cases, the probability distributions of such nodes are modulated by so-called risk factors (RF nodes). For example, the RF node “smoke” modulates both the prior probability distribution of “ischaemic cardiopathy” (i.e. P(isc. cardiopathy = yes | smoke = yes) > P(isc. cardiopathy = yes | smoke = no) and the conditional probability distribution of “cardiac infarct”. RF nodes are root nodes.

Finally, let us consider measures. A measure (e.g. in medicine, a therapy) is an action that has the purpose of decreasing the probability that a system anomaly is present. Measures are represented as states of a special A node. The A node is a root node. For each SA node the converging structure “SA → SAaf ← A” (where the SAaf node means “SA after measure application”) is defined.

2.2 Temporal structure

The passing of the time is represented as a sequence of time slices (for short, in the following, slice). In each slice a system monitoring session (for short, in the following, session) takes place. A session consists in a set of operations a user actuates in order to check the health of the system being monitored. More precisely, it consists in entering evidences (presence/absence of anomalous manifestations and risk factors), propagating them in the network, reading the occurrence probabilities of the HRE nodes (both in the slice of the present and in the slice of the future) and taking a suitable measure. A session takes place in the slice of the present.

For the sake of simplicity let us adopt the following limitation: temporal links between slices only concern SA nodes. The conditional probabilities of such links are dynamically calculated on the basis of temporal functions depending on the specific problem.

We want to avoid associating a physical instance of the causal network (sect. 2.1) to each single slice. We want to deal with only two networks: the network of the slice of the present (for short: network of the present) and the network of the slice of the future (for short: network of the future), with no limitation about the possible number of slices. To this end let us adopt a rolling-up based solution.

2.2.1 Network rolling-up

For each slice of the present subsequent to the first one, the network of the present is obtained by a rolling-up operation using the network of the future. However, such an operation requires the SA nodes of the network of the present to be root nodes. Unfortunately, an SA node may have one or more RF nodes as parent nodes. In order to overcome this problem let us adopt the following solution.

Let us suppose that the network of the present has at least one SA node that is not a root. In such a case let us perform the following operations. Let us acquire the probability distributions of the SA nodes resulting from evidences propagation. Let us eliminate, links from RF nodes to SA nodes, so that, at the end, each SA node is a root. Let the SA nodes prior probabilities assume the values of the above acquired probabilities. We have therefore obtained a new network of the present equivalent to the original one and in which every SA node is a root. The abstract network of Fig. 1 illustrates the network rolling-up concept.

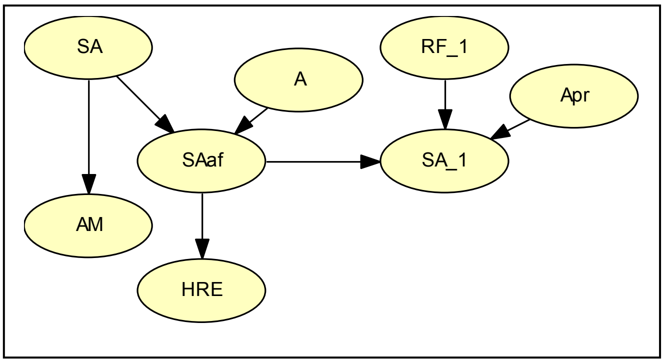

Fig. 1. The link SAaf → SA_1 is the temporal one. The nodes A and Apr (Apr means A in the previous slice) must be set with the same state. RF_1 represents a risk factor that might be present or absent in the time interval between the two slices. SA_1 represents SA in the slice of the future. The rolling-up operation consists in assigning the distribution probability of SA_1 to SA.

3 Site architecture

Around the core model a suitable set of Webpages must be developed so that the site actually results to be an aid for high risk events prevention. Let us examine the main features such a site should have. It should work playing four basic roles: session manager, decision assistant, history recorder, intelligent alerter.

3.1 Session manager

The session manager role enables a user to operate in the following way. A user starts a session by entering risk factors (if any) and then an initial set of evidences. He can simulate various cases by both updating the set of evidences and selecting alternative measures. In the middle of a session he must be able to suspend the session and resume it in a subsequent time. Let us note that all the session operations take place in the same slice of the present. Once the set of evidences and the choice of the measure are definitive, the user clicks on the session termination command. As a consequence the slice of the present gets closed too.

After a certain time the user can start a new session. A new slice of the present is then created with a new network of the present. The network is initialized with: prior probabilities inheriting the past, risk factors (if any) that concern the time interval passed from the last session termination.

3.2 Decision assistant

The decision assistant role enables users to find answers to questions like: “given the set of entered evidences, if I took a certain measure, which occurrence probabilities would the high risk events (considered in the core model) have in the slice of the present and in a certain slice of the future? Which measure should I take in the slice of the present to decrease the occurrence probability of a certain event in a certain slice of the future? At which date the occurrence probability of a certain event exceeds a given alarm threshold?

3.3 History recorder

The history recorder role enables users to get session summaries concerning both the current session and the past ones.

3.4 Intelligent alerter

This role consists in providing the following service. Users who have enabled the alerting service are periodically alerted via e-mail in the cases in which it happens that, at a certain future date, the occurrence probability of at least one high risk event exceeds a given alarm threshold.

4 Conclusion

Let us turn to the initial and fundamental claim: sites must behave like knowledge-based inferential machines in order to provide users with intelligent services. It has been shown how important it is that sites are able to reason about the future too. DBN has been presented as a powerful tool suitable for representing causal knowledge and temporal changes of the world, and reasoning under uncertainty. Given that, a method for building a DBN model and embedding it in a site devoted to personalized prevention of high risk events has been presented.

The proposal has been implemented (by the author) in a prototype site and has been tested by using a case drawn from the medicine field. The method is general and can be applied in heterogeneous fields.

Future works include an experimentation of the general guide-lines of the method in the marketing field: promoting the right things to the right users at the right time.

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