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Infobuttons and classification models: A method for the automatic selection of on-line information resources to fulfill clinicians' information needs

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Abstract

Objective. Infobuttons are decision support tools that offer links to information resources based on the context of the interaction between a clinician and an electronic medical record (EMR) system. The objective of this study was to explore machine learning and web usage mining methods to produce classification models for the prediction of information resources that might be relevant in a particular infobutton context.

Design. Classification models were developed and evaluated with an infobutton usage dataset. The performance of the models was measured and compared with a reference implementation in a series of experiments.

Measurements. Level of agreement (κ) between the models and the resources that clinicians actually used in each infobutton session.

Results. The classification models performed significantly better than the reference implementation ($p < .0001$). The performance of these models tended to decrease over time, probably due to a phenomenon known as concept drift. However, the performance of the models remained stable when concept drift handling techniques were used.

Conclusions. The results suggest that classification models are a promising method for the prediction of information resources that a clinician would use to answer patient care questions.

Keywords: Information storage and retrieval; Machine learning; Computerized medical record systems; Infobuttons; Web usage mining

1. Introduction

Clinicians face numerous information needs during their patient care activities and most of these information needs are not being met [1–6]. In a seminal information needs study, Covell found that primary care physicians in an outpatient setting raised two questions out of every three patients that were seen [1]. A more recent study showed that little progress has been made in meeting these needs [5].

A good portion of these information needs are related to gaps in medical knowledge that clinicians need to fill in order to make or confirm a patient care decision [6]. The impact of these gaps on the quality of care has been studied. For example, Leape et al., reported knowledge gaps as being one of the most important causes of medication errors, accounting for 29% of adverse drug events [7]. Likewise, knowledge gaps due to rapid advances in diagnostic technology are one of the causes of inappropriate laboratory test ordering [8]. Inappropriate or unnecessary ordering has been estimated to affect 5–50% of all inpatient laboratory test orders, increasing healthcare costs and potentially leading to patient harm [9].

Since the advent of the World Wide Web, numerous online health information resources have become available.

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These resources have demonstrated great potential to solve many of these information needs [10,11]. However, a number of barriers, particularly lack of time and seamless access to resources, preclude a more frequent and efficient use at the point of care [5].

"Infobuttons" are tools that access information resources, guided by contextual information from within an electronic medical record system (EMR) [12–17]. Infobuttons are being developed based on the theoretical principle that the context of a particular problem dictates a worker's information needs [13,18]. If true, then a decision support system should be able to predict the information needed in the context of a specific interaction between a user and a clinical information system. Infobuttons are an example of such a decision support system. After clicking an infobutton, the clinician is offered a list of resources and content topics that are deemed to be relevant in the given context [13]. Previous studies have demonstrated the usefulness of infobuttons in terms of reduction in time spent looking for information, increased use of information resources, fulfillment of information needs, and user satisfaction [15–17].

Infobuttons are typically implemented with a software component called the "Infobutton Manager", an approach that decouples the infobutton logic from components of the EMR system [13–15]. The core of an Infobutton Manager is a knowledge base composed of "mappings" among context instances and the resources and content topics that infobuttons offer (Fig. 1). For example, a physician ordering medication for a 3-year-old patient might be interested in a resource that provides the pediatric dose of this medication, while a care manager looking at a problem list of a patient with diabetes mellitus may wish to obtain patient education handouts about diabetes.

Infobutton Managers share the advantages of knowledge-based systems, especially the ability to change the knowledge content while not affecting the applications that rely on it. Ultimately, the role of an Infobutton Manager is to offer links to relevant content in a particular context of use. When an Infobutton Manager fails to provide links to relevant content, clinicians may become frustrated and consequently surrender their search effort, leaving their information needs unmet. Moreover, doubts concerning the effectiveness of the technology may lead them to ignore the presence of infobuttons in the future, leaving important clinical questions unanswered. A limitation of current Infobutton Manager implementations is that the mappings in the knowledge base are developed and maintained manually. This restricts the number of attributes that can be used for prediction purposes to those that can be managed effectively by hand and that are determined important enough by the designers. Likewise, the number of resources and content topics that can be offered is also constrained [19].

We hypothesized that using improved methods of associating various context instances with prior information seeking behavior will lead to a better prediction of the resources and content topics being sought by an infobutton user.

We have been investigating the use of machine learning and web usage mining methods as ways to improve the prediction model upon which Infobutton Managers are currently based. In a preliminary study, we explored the feasibility of employing infobutton usage data to produce classification models that would predict the resource that a clinician is most likely to use in a given context [19]. The results of this previous study indicated that the classification models yielded a high level of accuracy in predicting the resources that clinicians actually consulted when using infobuttons in various contexts. These models performed significantly better than the current implementation at our institution (level of agreement in terms of $\kappa = .86$ to .88 vs. .39; $p < .0001$), suggesting that the use of one of these promising models would improve the effectiveness of infobuttons in a production environment.

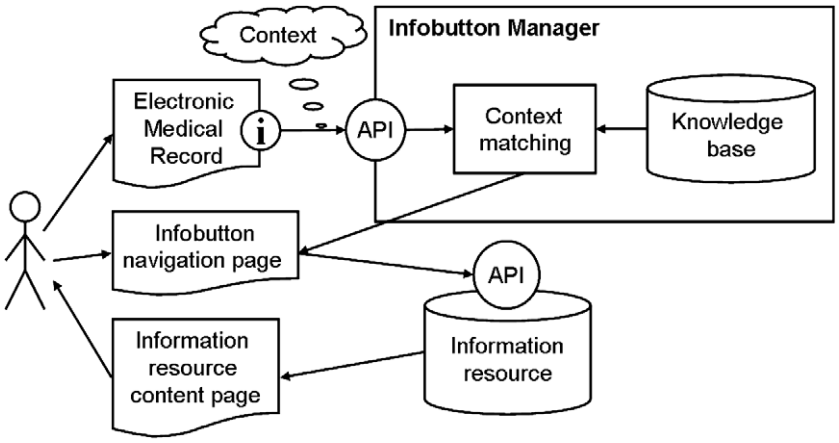

Fig. 1. Infobutton Manager architecture. When the user clicks on an infobutton, a request with context information is sent to the Infobutton Manager API. Next, according to a set of rules stored in its knowledge base, the Infobutton Manager selects the resources and topics that match this particular context (context matching). An infobutton HTML navigation page is produced with links to topics within the resources that were selected in the previous step (Fig. 2). Finally, the user selects a resource and a topic to look up and a request for content is sent to the selected resource.