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An Intelligent, Mobile Information System to Aid In-Store Purchase Decision Making

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Abstract: - Mobile consumer decision support is an emerging application domain for decision support systems. This paper describes the development of an intelligent, mobile decision support system that facilitates the task of product research for consumers on the go. It can be used on any mobile device and enables the customer to access valuable facts about a product when needed most – while being in a retail environment struggling with information overload. The software not only has to be able to identify appropriate recommendations and advice for each individual user, it is also used to reason with the huge amount of data found on the Internet, and in doing so must be able to retrieve specifically the information that is considered important to the customer in supporting his or her decision making.

Key-Words: - Decision Support Systems, Expert Systems, Knowledge Management, Information Retrieval, Intelligent Information Systems, Mobile Applications

1 Introduction

A common domain for decision support systems is the evaluation of retail products and helping the customer to select the best alternative from a given set of appropriate products. The challenge for most people is to be well-informed when walking into a retail store. Intuitively, everyone wants to know all relevant facts about a given product before buying it. But nowadays, people are overwhelmed by the huge amount of information that is available to them: product descriptions, technical terms, acronyms – something that Best Buy internally refers to as "feature vomiting" [17]. As a consequence, customers have to deal with an extremely large amount of information that they are not ready to "digest" in a short amount of time. In order to cope with these problems, people find other ways to access information that they feel plays a crucial role in their purchase decision – the Internet, an abundant source of information regarding all kinds of products. This led to the development of decision support tools that can be accessed online and help the user to dig through the available data, e.g. product search Web sites [9] and more advanced information retrieval tools [3, 21].

The wide spread of mobile devices like cell phones and PDAs gave rise to a related area, emerging from this domain, that is concerned about providing decision support while the user is in a mobile environment (e.g. [19, 20]). The hand-held computer serves as the user's front-end to access the online world "on the go" [16].

This paper describes the development of an in-store consumer decision support system for retail products. The software automates the product research by accessing the Internet remotely from an external server, gathering information about the desired product, which is then analyzed by an expert system. The latter takes into account the user's situation, product data, feature descriptions, other customers' evaluations and expert opinions. The result of the search, in the form of product information and recommendations, is then pushed to the customer's cell phone or PDA in condensed form, giving an overview of the most important facts that help make an informed decision on behalf of the customer. The prototype presented in this paper is an attempt to connect the user with the "online world" while being in a retail environment. An intelligent server performs the online product research on behalf of the user and reports only the most important facts through the wireless connection of the user's mobile device. This entails product information about a specific product the user is interested in, as well as the option of using the system as a virtual salesperson. The latter is asking the user questions in order to find out about his or her needs and to eventually come up with a list of recommended products for a given product category.

2 Background and Related Work

Information about a product is one of the most important factors in a customer's decision-making process. Apart from general sources of information, like advertisements, articles in magazines and newspapers and word-of-mouth, merchants are putting much effort into informing their customers in a better way. In fact, the need for such information is large enough that various third parties also address it. Moreover, a few retail chains have started to experiment with electronic aids that guide the shopper through the store, providing useful facts about the products on sale. While much effort has been spent on improving the overall shopping experience, not much has been done in terms of bringing knowledge from the outside of the store to the customer while he or she is shopping in the store.

2.1 Consumer Behavior

Numerous studies show that going to a retail store is still an important step in the whole shopping cycle for a couple of reasons. For one, the service personnel can help to find out about one's more specific needs, especially if one considers well-trained salespeople that know how to get to this kind of information by asking precise questions. Secondly, even people that are comfortable with using the Internet as a major source of information still want to see the product in real life before buying it [11].

This gave rise to a phenomenon that Forrester Research calls "cross-channel shopping" [7]. A customer falling into this category usually does extensive online product research, before going to a retail store to make the purchase (after having interacted with the product). The number of people who visit a regular "brick store" after doing online product research, and who are feeling well-informed and knowledgeable due to the acquired online knowledge, "remains steady at 75%" [2]. Another variant of this goes the other way round: people who did some online research, went to a store to interact with the product and then made the purchase back home at an online store. 69% of U.S. online shoppers admit to browsing in traditional stores before buying over the Internet [2].

Naturally, customers of the latter kind have recently been marked as "evil customers" by big retail chains like Best Buy, because they just use their facilities without ever buying anything in their stores. As a consequence, this group is considered to be part of the 20% of customers Best Buy wishes to ban from their stores [8].

2.2 Mobile Tools

The challenge with mobile consumer decision support is the fact that relevant information must be easy to access whenever the user needs it (i.e. in the retail store, facing complex decisions). The probably most popular attempt to push real-time product data to the user was undertaken by Google. They recently added a feature that allows querying for price information from the Web via text messaging on one's cell phone [10]. However, it fails to take into account the differences among the consumers perception of importance of information [21]. Information on prices might be an important factor in choosing the right store to purchase the product, but is less likely to help with evaluating the actual utility for one's personal situation.

A reasonable approach to provide the customer with more than just price information is to compute a "product attractiveness cue" based on the decision matrix for a given product category [18]. A decision matrix contains a list of products in rows with each of its attributes listed in columns. The cue is supposed to help the customer make a decision regarding a set of product alternatives. However, this system stores all product information locally on the PDA and makes no attempt to provide the user with real-time product information.

3 Prototype Development

Developing for mobile devices is a challenge that confronts one with several problems and constraints. Cell phones and PDAs or Smartphones have limited capabilities when it comes to memory requirements, computational power and user interaction [14].

This led to two conclusions. For one, running a full-blown intelligent decision support system on a mobile device is unlikely to succeed, mainly because of the computational requirements that would exceed the capabilities of a CPU on a regular cell phone and the low bandwidth usually available in cellular networks. Secondly, since it is not easy to browse the Web on a cell phone, no one is willing to do any kind of manual product research on the go with such a device. Moreover, reading from a small screen in noisy environments with bad lighting is a big hassle. Using the Web features on a cell phone will probably never go beyond activities that require less than pushing 4-5 buttons at most.

Hence the system infrastructure is based on an external intelligent server system that communicates with a mobile device through its wireless connection. For the PDA, the solution was a Web portal that can be accessed easily from the device's

Web browser. The Web site itself was laid out in a way that reduced textual input, the biggest hassle of mobile Web browsing, to a minimum. For the cell phone on the other hand, all interaction with the user is done via text messaging.

3.1 Information Retrieval

The main purpose of the prototype is to provide product information on a mobile platform for users on the go. This requires first and foremost accessing the Internet, a vast source of information, in a way that automates the product research for the user.

Moreover, we want to produce meaningful reports about the information that was gathered online in order to enable the user to be well-informed before making a purchase decision. These summary reports are created by the report generator of the expert system incorporated in the intelligent server, which will be further discussed in the next section.

In the traditional sense, information retrieval often means nothing more than the retrieval of objects holding information by the means of search [13]. For this prototype, we focused on a limited search on product information in only three sources: Amazon.com, Epinions.com and a local database containing specific product data on a number of products. The first Web site is widely known for its numerous product reviews and evaluations, and for being a platform for exchanging opinions on almost any given product in the form of customer reviews and product ratings. The second Web site also serves as a customer review forum, with a more extensive overview on prices and ratings from a greater number of different stores, thus not only focusing on Amazon's customer base. In addition to that, the name and the general product category for each individual product that were part of the experiment were gathered manually.

Each of these sources of information presents the available data and information in a different format. Amazon offers access to its product and customer review data bases through a Web service. A Web service is a set of self-contained functions that can be executed from anywhere in the Web using an XML-based protocol. The Amazon Web Services (AWS) offer methods for directly accessing their databases on product data, including, but not limited to, information about products, features, prices, average ratings and even complete customer reviews. Epinions on the other hand doesn't provide a Web service to access their data. The Web site is completely displayed in plain HTML, making it harder to extract information from it [1].

3.1.1 Amazon's Web Service

In general, Web services are used for exchanging data between applications on remote systems. Therefore they are widely used by companies who want to distribute information over the Web in a standardized format. The queries are sent to Amazon's Web service as a Representational State Transfer (REST) request, which basically encodes the requested method call into an HTTP post command [22]. In other words, the system loads an URL on the Web service server of Amazon and passes a number of parameters in a query string [4]. Since all the data are explicitly labeled, it is quite easy to transform them into facts that can be asserted to the knowledge-base of the system.

The system maintains a list of facts that are considered useful for the reasoning process, e.g. "price" or "customer rating". If the information retrieval yields such a piece of information, it is entered into the knowledge-base. Adding these kinds of facts activates the reasoning process, as more and more rules can fire with more data becoming available. It is important to note that all the retrieved data are stored in a temporary container, specifically created for each individual request and discarded after the session expires.

3.1.2 Epinions' Product Summary Page

Most Web sites providing information on products are not as easily accessible as Amazon's product database, due to the lack of an appropriate interface, like a Web service, to automatically gather data. In those cases, the Web site is retrieved in simple HTML format, which makes it harder to analyze. However, Web pages are usually well-structured and can be described by a formal grammar. Knowing the structure of the summary report pages for such a Web site enables the information retrieval module to extract certain information by searching the HTML documents for keywords and certain constructs (e.g. a certain table cell holding price information), without having to rely on natural language processing [12].

The Web site parser realized for this prototype simulates human interaction with the target Web site to get to the report page for a particular product. It can then go about loading the HTML document and parsing it line by line, searching for keywords that have been previously determined to lead to important facts that are usually contained in the summary. The keywords and constructs that the parser is looking for have been determined during an extensive analysis of the general structure of Epinions' report pages [5].

Since the parser is looking explicitly for predefined content, it is quite easy to break down the information and convert it into corresponding facts that can be asserted to the knowledge-base.

3.1.3 Integrating Sources of Information

In order to simplify the process of storing information, the data retrieved from Web resources are forced into a general pattern. The system uses information templates to store each element, which makes the search for information very explicit and dependent on the expert knowledge of what information contributes to the decision making process. In fact, the expert system and the information retrieval module work hand in hand, both incorporating knowledge about the process of doing product research. The information retrieval module includes implicit rules about what data to gather. The expert system on the other hand incorporates knowledge that deals with linking pieces of information together in order to come to accurate conclusions about what parts of the retrieved information are important. Which data are considered important has been evaluated in the planning phase preceding the development of the actual prototype.

3.2 Expert System

The other main pillar of the prototype is the Expert System module. Its purpose is to make sense of all the information that is related to the particular product or product category that the user is inquiring about. This not only entails product specific information like prices, features and average ratings, but also general information about consumer behavior, the product domain (e.g. “television sets” or “portable audio players”) and the act of shopping in general. The latter includes knowledge that an experienced shopper would have about making good decisions. These rules form the foundation of the Expert System’s rule-base.

In addition to that, the system can also function as a virtual salesperson, asking the user questions about his or her preferences until it can safely conclude which products are appropriate for that particular user. In order to be able to do this, we incorporated additional knowledge about the market, as well as the target customers for certain product categories.

In both cases, the overall goal is to perform an intelligent online product research for the customer, both reducing the time to do this type of research to a minimum and at the same time providing all necessary information on the go. This calls for a comprehensive summary report that contains all key elements of traditional, manual product research done at home. Hence the software agent doing the search has to identify all the important information and facts, and present it to the user in a condensed form that can be understood at a glance. In order to create a report for a specific product, the system will first retrieve all information about it and assert the facts to the knowledge-base. Carefully designed rules in the expert system will fire and yield certain hypotheses about the product and the importance of individual facts. These results can then be used to assemble a meaningful report.

3.2.1 Reasoning Process

The main goal of this reasoning is to determine how to prioritize the information that is available, such that the summary report will be most helpful to the user. Moreover, certain basic facts, such as product features, don't tell the user much right away. This wouldn't be an issue at home, when sufficient time is available to think about the implications that come with certain pieces of information, but in a mobile environment, the user expects to be presented with all the facts necessary to make an informed decision. Therefore, additional knowledge was incorporated that allows the system to examine the product's specifications more profoundly. For example, a cell phone comes with a camera. An expert shopper in the domain of cell phones would immediately look for connectivity features like Bluetooth, Infrared or USB, since the availability of a camera implies that the user will want to transfer the pictures to a notebook or desktop computer. The fact of whether or not the cell phone comes with such features suddenly becomes very important, climbing higher in the priority list. This translates to a rule that is fired upon encountering the fact that the cell phone ships with a camera and is missing all major means of transferring pictures to another device. The conclusion is that this should be seen as a major disadvantage as well as acknowledging the fact that the case has increased importance over other information. If, on the other hand, there was evidence that this particular cell phone has certain connectivity features, there would be no such issue and hence the importance of that fact would be much lower, decreasing its chances to appear on the report significantly.

Of course many facts are competing against each other in this process, for example price, rating, prominent feature, major disadvantage or other customer's opinions. Eventually, after all information is in and the inference engine comes to a stop, a hierarchy will have materialized regarding the importance of the individual pieces of information, which can then be used by the report

generator to lay out the summary report page. An in-depth description of the inner workings of this module can be found in [6].

3.2.2 Dealing with Uncertainty

It is the very nature of the problem addressed in this work that the information the system gathers is most likely to be imperfect or incomplete at best. In addition to that, we cannot be absolutely confident that our rule-base is absolutely correct in every aspect either. In fact, the domain knowledge incorporated into the Expert System might not be complete or even inaccurate. This is especially the case when dealing with subjective theories concerning consumer behavior and product evaluation, which are seldom provable. It is considered subjective, because many people would probably rate a given product differently, simply because everyone has a different opinion based on individual past experience and knowledge. The expert system therefore mainly incorporates knowledge that is considered common sense or would come from an expert of the domain, but still has to find a way to express the varying degree of certainty for each individual rule.

The expert system implemented in this prototype uses MYCIN-style certainty factors to address this problem. The approach explored by MYCIN was to incorporate this kind of uncertainty measure into the rule itself. Therefore, each rule has a certainty factor attached to it, reflecting to what extent this rule has an impact on the reasoning process.

In its simplest form, such a mechanism accumulates all evidence and calculates the certainty factors for the resulting hypotheses, allowing us to see which one has the strongest support. If there is some evidence to back a given hypothesis, it will increase the belief in it to some extent. This is a very linear and straightforward approach that can sometimes be mislead by insufficient evidence, because the certainty factor for a specific hypothesis is not high enough to reflect absolute confidence in it (even though it may be the highest ranked).

3.2.3 Report Creation

Once all priorities are assigned to the individual pieces of information, the report generator will be activated to create the summary report. For a query originating from a PDA or Smartphone, it will create a Web page that contains all the information and redirect the user to it. The report page has room for the product name and two columns holding information. The left column displays textual information such as customer reviews, feature descriptions and expert opinions. The right column holds three to four facts like price, average rating, major advantage or disadvantage and so forth. Each text or fact is generated as a link, directing the user to more detailed information on the respective topic if needed. In case the query came from a cell phone, the summary will be sent to the user's mobile device as a series of text messages with the same content as would have been displayed on the PDA. Each message contains a key code that can be used to retrieve more detail for the particular fact. The user would just send this key code to the server and receive another text message with the requested information.

Fig 1: Display of a regular cell phone showing the summary report. It is sent in multiple messages, depending on the amount of information retrieved by the intelligent server.

4 Conclusion

The development of the prototype presented in this paper was an attempt to combine the capabilities of an intelligent decision support system with the opportunities that lie within mobile communication. The main goal was to enable the customer to make informed decisions while in retail environments. Many people do online product research at home before visiting the store in order to feel well-informed. The prototype goes one step further by providing this kind of information automatically and in condensed form on the user's mobile device. Without any prior knowledge about the desired product, the customer is presented with key data that are crucial to make the right decision, including, but not limited to, price comparison, average rating based on different Web pages, textual information extracted from editorials, customer reviews and product descriptions and key features ranked by their importance – based on the result of the expert system's reasoning process. From a technical perspective, the implementation of the general

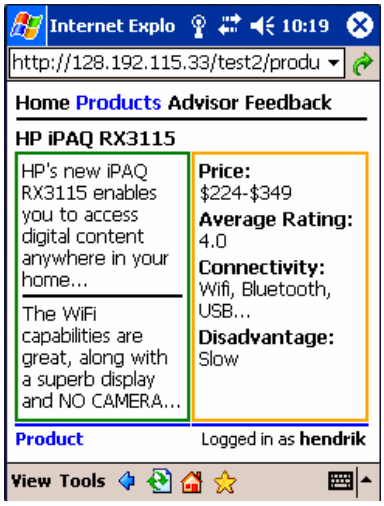

Fig 2: Summary of product research as displayed on a PDA. Each item has embedded a link that will yield more detailed information about how the fact was derived during the process.

infrastructure that connects an intelligent system on a remote server with any type or number of mobile devices was successful and proved to be stable. Moreover, the system succeeds in accessing multiple distributed databases over the Internet. This allows it to gather product data from various Web sites, broadening the spectrum of information sources and decreasing the risk of introducing a bias by acquiring data from one static source only. Most importantly, all the acquired information is processed by an intelligent decision support system that resides on a remote server. This guarantees that only the product data considered most useful for the user's decision making is pushed to his or her mobile device, making it easy to become informed about a particular product right on the spot.

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