INTELLIGENT TECHNIQUES FOR E-COMMERCE

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ABSTRACT

There is no review paper available on Artificial Intelligence (AI) applications to e-commerce to the best of knowledge. This paper is a survey of various AI techniques that are used in the design and development of e-commerce systems. The techniques are categorized into three groups namely, AI techniques for B2B e-commerce, AI techniques for B2C e-commerce, and AI techniques for both B2B and B2C e-commerce. In addition, this paper presents how the AI techniques are used in e-commerce.

1. Introduction

AI is the discipline that aims to understand the nature of human intelligence through the construction of computer programs that imitate intelligent behavior. AI techniques are successfully developed and used in most of the areas of science, engineering, education, business, etc. We use the terms namely *approaches*, *techniques*, *technologies*, *tools*, *methods*, and *systems* interchangeably in the rest of the paper. A complete list of acronyms is provided in the appendix.

E-commerce is the use of computing and communication technologies in commerce between some or all parts of a business and its customers. AI techniques are extensively used in the development of e-commerce systems also. The field of e-commerce can be classified as B2C e-commerce and B2B e-commerce, in terms of AI techniques involved in this field. In this paper, we present some important AI techniques that are useful in the design and development of e-commerce systems.

2. AI in Different Types of E-Commerce

AI approaches are useful in the development of B2C and B2B e-commerce systems. B2B e-commerce has around 80% share of total e-commerce market, and B2C captures the rest. But, much of the attention in AI for e-commerce development has focused on B2C transactions [Prasad 2001].

In B2C e-commerce, AI is used primarily for product selection and recommendation, negotiation, auctions, solving real-world scheduling problems and enhancing servers' scalability, generating automated responses, and decisions on bundling and pricing of goods, etc. In B2B e-commerce, AI is used mainly for supply chain management. AI technologies, namely ontologies are used in both the types of e-commerce systems. The following sections present the details.

AI in B2C E-Commerce

In this section we present some important AI approaches that are used in the development of B2C e-commerce systems.

AI in product selection and recommendation

AI is used in advising the users on the items they want to examine or purchase through the Internet [Driskill and Riedl 1998, Kautz 1998, Resnick 1997]. This kind of advice is necessary because there are no real persons to advice the customers in the Internet. This advice is helpful in navigating a large range of product descriptions. There are different types of product selection and recommendation approaches. Some important approaches are: ACF [Shardanand and Maes 1995], KB [Burke 2000], and hybrid. These approaches are explained.

ACF approach: This approach is based on "word-of-mouth" recommendations. This addresses the problem of capturing previous customers' recommendations/feedback on the products they have already purchased, and use this feedback in recommending the products to potential new customers [Hayes et al. 2001].

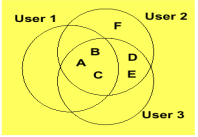

Figure 1: An example to explain ACF.

For example, in figure 1, assume that users 2& 3 are past customers and user 1 is new. All the users have common interest in features A, B, and C. Customers 2 & 3 purchased products D and E in the past. Due to the common interest, the products D and E are recommended to user 1 now. An example website based on ACF approach is [http://www.recommender.com]. This website is used to recommend movies for customers.

Some ACF systems can even provide the reason or data behind a recommendation [Herlocker et al. 2000]. The data is generally displayed in a graphical form such as chart. [http://movielens.umn.edu] is another movie recommendation website that can provide the reasons behind its recommendations. Most of the systems based on ACF approach utilize the following *mean squared difference formula* [Cunningham 1999]:

$$\delta_{UJ} = \frac{1}{|InCommon|} \sum_{f \in InCommon} (U_f - J_f)^2$$

This formula is used to calculate the difference between two persons *U* and *J*, in terms of their interests on a product. U_f and J_f are the ratings of *U* and *J* on feature *f* of the product. *InCommon* is the set of features of the product both *U* and *J* rated.

A main drawback with ACF approach is that it is not effective until a large number of users enter their profiles, and a sufficient number of rating items are available in the database.

KB approach: This approach is based on the knowledge-base of product information. Most of the knowledge-based systems for product selection and recommendation are either CBR or GBR type. These are explained.

CBR approach: CBR is a problem solving approach based on past experience. Past experience is organized in the form of *cases*, and is used to solve new problems [Prasad 1995]. Doctors, chefs, and lawyers are examples of case-based problem solvers because they use past cases in solving new problems. In product selection and recommendation, CBR works as follows.

Step-1: Accept user preferences. *Step-2:* Retrieve similar product offers from case-base and offer them to the user. Quit the process if either the user is satisfied with the offer or no longer interested in investigating an item. *Step-3:* Accept modified user preferences and go to step 2.

In CBR for product selection and recommendation process, each product is treated as a *case*. A widely used formula for CBR in identifying similar products is *nearest neighbour retrieval*. It is based on *weighted Euclidean distance* [Wettschereck and Aha 1995] and calculates the distance/difference between any two products. Some successful e-commerce systems using CBR include [http://www.hookemacdonald.ie] for virtual property letting and [http://www.reiseboerse.com] for last minute travel bargains. A most recent CBR-based system for recommending utilities in sports domain is [Prasad and Clementi 2002].

The main difference between CBR in general and CBR in e-commerce is that, in the first case there is no way of accepting a modified user preference.

GBR approach: This approach is used to find products similar to ones the user is already aware of. The basic idea is "similarities are goal-based". For example, an umbrella is similar to a raincoat if the goal is to protect from rain. But it is similar to a stick when the goal is to protect from a dog! For each goal, a similarity metric is defined between each pair of products and the metric gives how *close* the two products are, in terms of the goal. Systems based on goal-based retrieval approach are referred to as *findmeSystems* [Burke 2000] in the literature. Domain independent database browsing tools [Burke 1999] are also developed on top of findme systems. The tools are based on *preference-based navigation* methods. In these tools, each product is associated with a dropdown list of possible modifications to its features. The tools are useful for on-line information access, particularly for electronic product catalogues.

There are other kinds of KB approaches for product selection and recommendation. *Content-based retrieval approach* is an example of this. *NewsDude* [Billsus and Pazzani 1999] news filtering system is a content-based recommender system that recommends news articles, which might be of interesting to the users to read. This system is developed using *machine learning* [Mitchell 1997] techniques. As a result, the system improves its performance over time, by "understanding" its customer (user) better over time.

Hybrid approach: This is primarily a combination of ACF and KB approaches. In some systems, the ACF is used in the post processing stage and the systems are predominantly knowledge-based [Burke 1998]. Other systems [Tran and Cohen 1999] check whether there is sufficient number of feedbacks from previous users. This number is used as a threshold to decide what approach to be used. If the number is less than the threshold then a KB approach is used, otherwise ACF approach is used. The threshold value can be determined interactively based on the product and the business.

Some systems attempted to utilize CBR approach for ACF [Hammond and Schmitt 1994]. Some other systems [Bhargava et al. 1999] are based on *discrimination nets* [Barsalou and Bower 1984] of product features or *quantitative decision support* tools [Adelman 1992].

Apart from ACF, KB, and hybrid approaches, there are other product selection and recommendation approaches such as interviewing the user in order to know pair-wise feature importance [Branting 1999], forming user models based on observation of user decision making, either in response to system suggestions

("candidate/revision" or "learn-on-failure" [Maes 1997]) or through passive observation [Dent et al. 1992] of the decisions, and learning customer preferences by observing customers' selections from return sets [Branting 2001].

AI techniques are also used in the development of dialog-based product recommendation systems [Chai et al. 2002]. These systems are based on *statistical parsing* techniques [Charniak 1997] and *rule-based* AI techniques [Golshani 1990]. One such system is currently in use at IBM's website to recommend laptops to potential customers.

AI in online negotiation

Negotiation takes place when a buyer (i.e., user) likes a product and there is at least some conflict of interest between the buyer and the seller. Negotiation is a process with the goal of intended benefit, in which the buyer and the seller bargain resources such as price, product features, etc.

CBR approach is extensively used for negotiation [Kowalezyk and Bui 1999]. According to [Wilke et al. 1998], some important characteristics/methods to represent a CBR-based negotiation process are: active or passive agent method, single or multiple dimension modification, over- or under- specification of customer demands. The methods are explained here. Active agents explicitly suggest refinements/modifications to customer demands. The customer finally finds a satisfying product or exit after a few iterations. For example, if the customer is looking for a required television set then the system may modify one or more specifications such as size, color, etc. Passive agents can only provide different methods for the user on how to change his demands. For example, if the product is a television set then the system can only specify the user on what attributes and how they can be changed. Most recently, hybrid agent approaches are developed [Pradeep 2003]. In these approaches, the agent acts as an active agent for user's high priority features and acts as a passive agent for the low priority features. In case of modification in single dimension, it is possible to change only one feature of the product during one negotiation cycle. For example, in previous examples, if it is possible to change either the size or the color of the television (but not both) in one cycle, then the modification process is of single dimension type. But in case of modification in multiple dimensions, more than one feature can be changed in a single cycle, and this leads to faster convergence of negotiation process. With over-specified constraints/demands, it may not be possible to find a suitable product as no single product may satisfy all the demands. For example, if a user is looking for a television set with many constraints such as size, color, manufacturer, model, screen-type etc., then the chance of getting a matching product is less. The demands need to be relaxed eventually. Under-specified demands may cause retrieval of too many products. For example, if a user simply specifies a black color television then hundreds of product specifications may be displayed. In that case, more demands need to be imposed during the course of negotiation.

There is another kind of CBR approach for negotiation. It is based on *agent technologies* [Tecuci 1998]. In this approach, negotiation agents use *episode strategies* to incrementally modify offers or counter-offers towards an agreement [Wong et al. 1999]: If O(1), O(2),…O(n) are series of offers then the concession C(i+1) in the episode strategy S(i+1) is determined as $C(i+1) = [\,[O(i+1) - O(i)]/O(i)\,] * 100$ %. A list of concessions is designed in this fashion. The concessions applied in previous episodes are reused when a similar negotiation situation arises. Also, there is an approach based on *Bayesian learning* [Siriwan and Sadananda 1999, Zeng and Sycara 1998]. Bayesian learning is used to learn negotiation strategies. A sample negotiation system for product representation and message passing between a buyer and seller is presented in [Su et a l. 2000]. User can specify product attribute values, constraints between the attributes, negotiation strategic rules, etc., for negotiation.

AI in online auctions

As of today, there are around 200 online auction sites on the Internet. Most of the online auctions are *common-value auctions*. For example, auctions for cars or computers. Configurable agent techniques are generally used to represent users in online auctions [Hu et al. 1998]. The agents can be configured, initiated, and monitored from an online interface.

In general, "winner's curse" happens if a bidder has big positive error in his evaluation. If a customer can evaluate the item correctly then he may avoid winner's curse. In order to evaluate the item more correctly, the user needs to find or approximate the market price of the item, because the market price enables the customer to evaluate the item more correctly. User can bid for optimal price of an item if he predicts the item's market value. Information gathered from different auction sites provides useful information on the item's market value. But it is a difficult task for a user to work with multiple auction sites simultaneously. AI approaches are used to help customers. They are used for information gathering and prediction purposes [Ito et al. 2000]. These approaches are based on agent technologies. They incorporate a number of bidder agents and a master agent to coordinate them. Different bidder agents are assigned to different auction sites. The agents simultaneously monitor prices of an item at several auction sites and cooperate among themselves, with the help of the master agent, to arrive at an estimated value of the required item. In reality, a user approximates a market price based on price information gathered by the agents.

AI in solving real world problems and for enhancing server scalability

E-commerce servers should be able to solve realistic problems. In a travel domain, finding the flights with restrictions such as fare, schedule, safety, and break-journeys etc. is an example of a real world problem. E-commerce servers should also be *scalable*, so that they can be accessed by a large number of customers simultaneously.

Smart client techniques [Arnal and Faltings 1998] are used for above purposes. Smart clients are based on CSP methods and provide solutions for catalogue-type e-commerce systems. In these systems, basically the user supplies a query to a client machine. The client machine forwards the request to server. The request contains constraints specified by the user. The server accesses the database of product information and generates a CSP. The CSP is added with a search algorithm. The resultant information is sent back to the client. The user can browse the information at client site to see various solutions. Smart client techniques are efficient autonomous problem solvers, and the information they produce is small enough to be sent over the Internet in a short time. Formation time of a CSP is very less when compared to the time for solving the CSP. As a result, the agent execution at client locations drastically reduces the workload on the servers. An example on how the smart client techniques are used in air travel planning domain is available in [Arnal and Faltings 1998].

AI in generating automated responses, bundling and pricing goods

Providing automated responses eliminate the need of skilled persons to answer customers' queries [Lallemant and Fox 1998]. If a producer has different goods then he can bundle and price them in different ways, such as per article pricing, pure or mixed bundling, etc [Brooks and Durfee 1999]. To attract more customers, the producer has to take decisions regarding what goods he can offer, how to offer, and how the goods should be bundled together and so on. Different satellite television packages with different price listings, available to us in the present day market, are example of this. Proper pricing and bundling decisions are vital to expand the customer-base and also to increase profits. Traditionally human beings take these decisions. Automated decision-making ease human beings from this complex task of decision-making.

C*lassification* techniques [Prasad 1995] are extensively used for these tasks. The relationships such as sub-class, super-class etc., between different classes of objects is used in building classification systems. *Decision theoretic* approaches [http://www.ratio.huji.ac.il] are also helpful in making suitable decisions.

AI in developing buyer agents

AI techniques are also useful in development of *buyer agents*. Most of the e-commerce services are viewed as "sellers" agents because their goal is to push services and/or merchandise on to the users. Buyer agents work for the buyers rather than the sellers. The aim of the agents is to educate the user to become a more informed customer. Some key responsibilities of such agents are: informing customers of complex interactions between specified preferences (for example, the relationship between the cost of additional insurance for a product and the guarantee period of the product) and prevailing market conditions, and use of ontology to help the user formulate queries, and providing alternate products [Sen 1999].

AI techniques are also used in B2B e-commerce. The details are presented in the next section.

AI in B2B E-Commerce

SCM is the key factor for successful B2B markets. As a result, it is the key for B2B e-commerce also. The rise of e-commerce has further heightened the importance of SCM as companies reengineer processes as they are moved online [Fenstermacher and Zeng 1999]. "A supply chain is a network of autonomous or semiautonomous business entities responsible for procurement, manufacturing and distribution activities associated with one or more families of related products" [Swaminathan et al. 1997]. An integrated supply chain makes businesses to share real time information and significantly reduce the inventory carrying costs. This is very important for B2B e-commerce. A number of AI-based SCM problem solving approaches are available. Most of them are agent-based and each agent is responsible for one or more activities of the SCM. Most agent-based approaches for e-commerce are focused on transactional knowledge, i.e., knowledge required to agree on price, delivery date, quantity of the products etc., and these approaches treat the problem as a centralized CSP [Sun et al. 1998]. This is because, nowadays communication in supply chain is not between pairs of members but between all the members of a given supply chain. In centralized CSP approaches, SCM problem is mapped onto a CSP, and a suitable CSP algorithm is used to solve this.

Some agent-based approaches can handle knowledge beyond transactional, and can incorporate the knowledge of SCM [Fenstermacher and Zeng 1999]. Some agent-based approaches for solving SCM problem can model human beings or organizations. The models are used for simulation purposes and risk benefit analysis [Swaminathan et al. 1998].

There are systems that utilize agents for sub-contracting [Kim et al. 1999]. In sub-contracting systems, the supply chain coordination is transformed to virtual supply chain in a multi agent system through the negotiation among software agents.

Information exchange is vital in both B2B and B2C e-commerce systems. Ontologies are used for this. They are explained in the next section.

AI in Both B2B and B2C E-commerce

A number of e-commerce systems are developed, configured, and used by different organizations for a variety of business purposes. They require rich format of data to exchange in both B2B and B2C e-commerce purposes. Standardization of business models, processes, and knowledge structures for information exchange are vital in achieving the promised *return on investment* [McGuinness 1998]. The main obstacle to successful e-commerce is to get systems that can meaningfully share information [http://www.semanticweb.org]. Ontologies are vital in achieving this goal. They fundamentally stand for vocabulary for basic terms and their meanings between members, either real or virtual, of a community of interest. The purpose of ontologies is to enable communication between computer systems and/or persons in a way that is independent of the individual system technologies, information architectures and application domain [http://www.ontology.org]. Ontologies are very important for collaboration, agent-to-agent communication, knowledge management, and for different database systems to interoperate [Thuraisingham 2001].

Although there are no domain independent ontologies existing as of today, we observe that the following knowledge representation methods are used in constructing ontologies for many domains: *concepts, relations, instances*, and *axioms*. A concept represents a set of entities or 'things' of a domain. For example, the set of desktop computers forms a concept in the domain of electronic items. Relations describe the interactions between concepts or a concept's properties. For example, a relation may specify how the prices of desktop computers vary with their processing speed. Instances are specific instantiations of concepts. For example, a desktop computer in a lab is an instance of the computer "concept". Since an axiom is a conceptualisation of the domain, ontologies should not contain any instances. Finally, axioms are used to specify constraints on the values for classes or instances. The upper limit on the processing speed of a desktop computer is an example for axioms.

XML is accepted as the emerging standard for data interchange on the Web. But the level of XML data model is too low to represent data at conceptual level. But, due to market dominance of XML, it is desirable to exchange ontologies using an XML like syntax to develop parsers easily. Due to these facts, XML-based languages are mainly used for developing ontologies. These languages are defined on top of XML. Some example languages are: XOL [http://www.ai.sri.com/pkarp/xol/xol.html], OIL [http://www.ontoknowledge.org/oil] etc. They use XML syntax with slightly different tag names and can represent conceptual meaning.

3. Conclusions

This paper presents some important AI techniques that are useful in the development of e-commerce systems. We have divided the AI techniques into three categories: those used in B2C e-commerce, those used in B2B e-commerce, and those used in both the types of e-commerce systems.

According to a report published in Dataquest®, worldwide revenue projection for e-commerce is expected to be US $ 380 billions by the year 2003. In the United States alone, the projection is US $ 147 billions, and in Europe it is US $ 115 billions. Currently, more and more people and organizations are realizing the need of AI techniques in e-commerce applications.

We hope that in future, AI plays a greater role in the development of e-commerce systems. Hope, more smart results may be developed for B2C e-commerce. We expect more research and development take place in applying AI to B2B e-commerce. AI techniques combined with XML, UML and other object-oriented technologies may lead to more useful techniques for information exchange in e-commerce. The rest of the conclusions focuse on how future AI applications to e-commerce can be evaluated.

One of the basic aims of AI is to build systems that can mimic the behaviour of human beings. By adding AI components, an e-commerce system should behave more "natural" to its users. For example, recommender systems. Like any other technology, AI should also enhance the efficiency/performance of an e-commerce system. Efficiency is in terms of producing fast and elegant solutions and consumption of less system resources. For example, smart client techniques and AI-based SCM solutions are aimed at achieving this goal. Development of domain independent ontologies and/or development of ontologies for complex domains are very important for successful communications with e-commerce systems. As a result, any AI research that can enhance this dimension is useful. In conclusion, naturality, efficiency, and providing better interface (i.e., better interaction facilities) are some important dimensions that can be used in assessing and evaluating future AI applications to e-commerce.

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APPENDIX

A glossary of acronyms is provided:

Artificial Intelligence	AI
Automated Collaborative Filtering	ACF
Business to Business	B2B
Business to Customer	B2C
Case-Based Reasoning	CBR
Constraint Satisfaction Problem	CSP
Goal-Based Retrieval	GBR
Knowledge-Based	KB
Ontology Interchange Language	OIL
Supply Chain Management	SCM
eXtensible Markup Language	XML
Ontology Exchange Language	XOL