



Evaluating customer aid functions of online stores with agent-based models of customer behavior and evolution strategy

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ARTICLE INFO

Article history:

Received 16 November 2008

Received in revised form 16 November 2009

Accepted 26 December 2009

Keywords:

Agent

Evolution strategies

Customer aid function

Online store

Recommendation

ABSTRACT

With competitive pressure growing in online markets, many Internet stores provide various customer aid functions such as personalized pages to help customers shop more effectively and efficiently. Evaluating such customer aid functions is usually costly because it requires full or partly-working systems and many human testers. In order to address this problem, this research presents a novel approach to evaluating customer aid functions with agent-based models of customer behavior and evolution strategies. Agent-based modeling is used to imitate users' rational behavior at Internet stores with regard to browsing and collecting product information. It is assumed that users evolve their browsing skill and strategy over time, to maximize the efficiency and effectiveness of their shopping, and hence, evolution strategy, an optimization method, is combined with the agent-based model to find the rational behavior of each user. The rational behavior is then used to simulate the virtual shopping of users and to evaluate the performances of target customer aid functions. Several experiments were performed to illustrate the use of the approach, where the personalized recommendation page of a virtual online DVD rental store is evaluated in comparison with more general functions such as listing most popular products or sorting categories. The results show that a personalized page might not always be the best customer aid function for all users compared to the simpler ones.

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1. Introduction

With e-commerce maturing across industries and countries, being able to sell products or services online no longer gives much competitive advantage to businesses. Any company is now able to quickly build an e-commerce infrastructure and launch services with readily available technology solutions and the use of development experts at low cost. One of the efforts that many companies have made in order to survive in this competitive environment is to develop various customer aid functions that can provide a more satisfying shopping experience to customers when compared to rival Internet stores.

There are many such customer aid functions that range from simply assorting products in various ways to providing intelligent personalized services. For example, many stores such as Amazon.com recommend products in several different ways, according to individual customers' activities or transaction history [33]. Many stores also have personalized pages that provide a list of recommended products, information, or advertisements that are prepared according to the estimated preference of each customer, based on their activities or transaction records. There are also simpler and non-personalized recommendations provided in many stores that show the lists of best selling products, top-rated products, most-clicked products, etc. Simple customer aid functions are relatively easy to build, but sophisticated methods such as personalization often require advanced techniques based on statistics or artificial intelligence.

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The main goal of this research is to develop a novel method of analyzing and evaluating the usefulness of such customer aid functions by developing an agent-based model of customer behavior and applying evolution strategy, an optimization technique, to the model. Therefore, this research first develops an agent-based model of individual customer's behavior with parameters that can represent the different behavioral characteristics of individuals. Then, evolution strategy is used to identify the optimal or rational behavior of each customer by optimizing the parameters of the agent-based model for each shopper. The results of the optimization are used for simulating the behavior of each customer and the simulation results are analyzed to evaluate the usefulness of target customer aid functions.

Compared with many other methods or guidelines for evaluating user interfaces or web personalization methods, there are several advantages to this approach for evaluating customer aid functions. First, the approach attempts an experimental analysis without requiring the implementation of customer aid functions or expensive empirical studies involving many human participants [26,52,56]. Similarly, the approach is also different from many software testing methods that mostly focus on finding errors and defects in software, where again the implementation of such software is needed, along with the participation of human testers [9,50]. Second, while it is usually difficult to quantify many general measures of design principles or web-site evaluation frameworks for the automated evaluation of customer aid functions [11,20,54], this approach enables the simulated analysis of customer aid functions using direct measures of effectiveness and efficiency.

In order to illustrate this approach, a series of experiments were performed using a virtual online DVD rental store, composed of publicly available datasets. In the experiments, the usefulness of some customer aid functions was evaluated in comparison with others.

The paper is organized as follows. Section 2 gives a brief overview of the related literature. Section 3 presents the agent-based model of customer behavior and shows the application of evolution strategy to the model. Section 4 shows the results of the experiments. Section 5 discusses the results followed by the presentation of the conclusion in Section 6.

2. Overview of the related literature

2.1. User interface evaluation and software tests

Many methods have been developed to date for evaluating user interfaces or for testing software in software engineering, management information systems (MIS), and e-business fields. Many of the methods were originally developed for traditional non web-based applications, but have been extended or modified to test and evaluate web applications as well.

Such methods can be broadly classified into a couple of types. First, there are design guidelines or principles that developers can use when creating user interfaces. They are often a set of recommended design features that constitute good design or a list of those which should be avoided. Readers can find recent works of this kind for web sites [20] as well as many non web-based desktop applications [50]. Similar to the works above, there are also many evaluation frameworks used mostly for evaluation purposes [32,46,54], rather than for design.

Second, there are various methods of testing for different aspects of software and for different stages of development. For example, a popular book on software engineering classifies testing into component testing and system testing, where the former tests individual components and the latter tests the integrated system [50]. Depending on the various foci of software tests, they can be further classified into many different types such as black vs. white box tests, unit vs. integration tests, and alpha vs. beta tests, just to name a few.

Although there are some similarities between this research and the methods noted above which evaluate and test software, a direct comparison is not possible. Many design guidelines, principles, and evaluation frameworks are very useful in designing general user interfaces, but they cannot be used easily to measure how effective a specific customer aid function will be in terms of improving customers' task performance, especially in comparison to other functions for different types of users. Software testing methods usually focus more on checking if the system meets its requirement specification, or finding any defects and errors in the system, rather than proving how effective the system is in improving the performance of the users' tasks. Even though there are some software tests that examine user acceptance or usability [9,50], these methods are still very expensive because they require full or partially working systems with the help of human testers. In contrast, this research aims to design a method for the automated evaluation of customer aid functions without the need for implementation.

2.2. Personalization at Internet stores and the evaluation of personalization methods

Among many customer aid functions, this research targets personalized pages for applying and illustrating the use of the customer behavior model. Personalization has received considerable attention with the proliferation of online services. Personalization usually refers to the presentation of products, services, or information to customers, tailored according to the individual user's preferences which is assessed by various methods, usually using data collected through online transactions. One of the most popular applications of personalization at online stores is the personalized recommendation of products. For example, online stores such as Amazon.com recommend products to customers whenever they click on a product within the store [33]. The recommendation is based on the similarity between the recommended products and other products that have been previously clicked or purchased by the user, or the similarity between products that are often purchased together by

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