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A feedback control approach to maintain consumer information load in online shopping environments

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ABSTRACT

The heterogeneity of e-commerce users requires online shopping environments to advance from a simple framework to one that is adaptive. This need results from the negative consequences of user frustration due to information load. We used a feedback control theory based approach to address the online consumer information overload issue in an adaptive manner. To demonstrate the efficacy of this feedback control approach, a design science method evaluated the feedback controller. The main effect was that the dynamic adaptivity did not have to rely on summarizing data for inference to the individual. The proposed feedback control design is therefore a robust and viable option for organizations to incorporate into their online shopping environments to accommodate user variation of information load for e-commerce adaptivity.

1. Introduction

We used a feedback control model to maintain a reasonable consumer information load in the context of online shopping. The negative impact of increased information overload in such environments affects consumer emotions and shopping behavior, as well as decision quality [12]. However, information overload varies from person to person. To accommodate such variation, online shopping websites are moving from a simple, single model to one of adaptivity.

The issue of increased information load remains problematic as users of online shopping websites search for products and often receive an overwhelming number of possible product variations. Information overload occurs when too much information is provided, leading to increased frustration and stress. For example, when attempting to purchase a computer at a computer e-commerce website, the customer may be presented with a list of over 900 possible configurations. A large list of product options requires longer to absorb and can be overwhelming, leading to buyer frustration and sub-optimal decision making [9].

Prior research has examined information overload issues in the context of decision support tools that adapt to the user. Such adaptive decision support tools provide search and navigation, presentation, recommendations, and the use of agents [15,16]. Adaptive search tools improve navigability while adaptive presentation tools improve content understanding. Recommendation agents are another means of adapting to the user; they may provide content links or suggest alternative products.

Although beneficial, these tools have limitations; they require prior data input from each individual (i.e. answering questions on his or her preferences). While adaptive tools may relieve the effects of information overload, they are not a panacea. Furthermore, information filtering does not consider differences between individuals. We followed a design science method [4] of building and evaluating a feedback controller for online shopping websites as a means to address this issue.

The appeal of feedback control within an e-commerce shopping environment is that it is adaptable to the individual and does not require a request for direct user input. The feedback control design takes into account the user's online behavior; using it allows the website to control information load by determining the number of choices to display to the customer. The design notes the time taken to decide for the number of choices provided when the user interacts with the website. Thus, if the first iteration provided too little choice, then the next set of choices would be larger. In this way, the information load is maintained essentially constant. It is beneficial to use dynamic online behavior as an input for controlling information load, as this takes individual differences in information processing abilities into consideration.

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We used the design steps of feedback control theory to stabilize the information load and evaluate the efficacy of the feedback controller by developing a simulation of the process. The results showed that the design stabilized information load, and was a viable method for adapting to individual user needs.

2. Related work

2.1. Adaptive decision support in online shopping environments

From an e-commerce perspective, the goal of adaptivity is to customize product choice to the individual user's needs, whereas, from a user perspective, an e-commerce website that provides too little or too much information on product choice is likely to be unacceptable. Lack of information is limiting and can lead to the risk of a sub-optimal decision, while too much information can lead to sub-optimal decision making, because the user is overwhelmed and becomes frustrated. Decision support systems provide several ways to approach adaptivity in the hope of providing the right amount of information [5].

Traditional DSS incorporate three components: data, model, and interface; whereas an adaptive DSS integrates an additional component within its architecture, *adaptation*. Dynamic systems possess the property of *adaptive self-modification*, whereas all others are classified as static.

We distinguish the multiple approaches to adaptivity from an e-commerce perspective by focusing on two general characteristics: first, "how past user information is utilized" (individual and aggregate information) and second, "how the choice set is presented". The first characteristic is for the purpose of providing the current user with product options, ranging from the aggregate (using information from previous visitors to the website to adapt to the current user), to the individual level. The second characteristic relates to the choice set presented to the user; this ranges from discrete (that contains a finite number of alternatives) to continuous. In terms of e-commerce, a user who intends to purchase a computer may enter 'computers' in the search box with the results showing a choice set of all computers that the e-commerce vendor has in stock. This discrete choice set is not adapted in any way to characteristics of the current or previous user purchases.

Prior research on aggregation approaches, including the use of recommendation agents (RA), has shown that they are useful in lowering information load. There are two types of recommenders: content based (using information from past purchases or preferences for new recommendations) and collaborative filtering (based upon user's ratings of products). The assumption is that users who give similar ratings on the same products have similar tastes.

Aggregate customization is another way of using information in aggregate to create a customized experience for the user. Arora and Huber [1] used aggregate customization of product choice sets. In their study, they expected that choice set information from a small sample of users could be used to create a common customized design for the average user. In addition, Bucklin and Sismeiro [2] used web server log files to create models for predicting user browsing behavior. One drawback of the aggregate models is their inability to account for individual differences from summary data.

Acknowledging the difficulty of capturing user differences with aggregate information, some researchers focused on adaptivity at the individual level. Toubia et al. [14] proposed an alternative approach for choice sets based on a question-design method. Their choice set individually adapts to the user based upon previously answered questions. Other researchers included the use of algorithms that provided individual adaptivity of user choice sets as well as an application of optimal control theory to determine the optimal choice set available to individuals [10].

2.2. Feedback control

For our feedback control solution, we use the real-time online behavior of the user and do not require specific input. Thus, the user's online behavior becomes the system input that determines the desired output (e.g. number of choices). Utilizing a user's online behavior takes into consideration his or her information processing ability and the differences between individuals when shopping online. From the perspective of real-time adaptivity, feedback control is common in engineering, control, operations, and transportation disciplines. Recent research, however, has expanded feedback control theory to a larger number of application areas.

Since uncertainties or disturbances exist within any real system, the objective of the design is to control the output. For our purposes, the feedback controller designed for online shopping environments controls the load by manipulating the number of choices displayed to the individual. Control systems can either be open or closed loop. An open loop system does not take into account real-time information about how the system is performing. A closed loop system however, incorporates the feedback of the system output to change the input to obtain the desired output.

Feedback control theory is based on a mathematical model of the system that is to be controlled. This model is used to develop a mathematical model that provides the desirable closed loop properties of the system. A nominal model is created because the parameters of the model are not precisely known. The mathematical model, however, is generally robust because of the (negative) feedback nature of the system.

Performance criteria derived from the fundamentals of control theory have been developed and used to evaluate the feedback controller under various information load conditions. The criteria are stability, settling time, steady state error, and robustness. For our feedback controller, a *stable* system means that the information load is bounded by having a large enough choice set to satisfy the number of choices computed by the feedback controller. *Settling time* is the time taken to converge to the desired information load and achieve steady state. *Steady state error* is the difference between the desired and the actual information load. Lastly, the feedback controller performance is evaluated by its *robustness*; that it performs well in spite of uncertainties or disturbances.

One advantage of a feedback control design is that the model of the system to be controlled does not have to be exact, but it should contain its essential dynamic features. Any mismatch between the model and the actual system is normally handled by the robustness of the feedback controller. The ability of feedback controllers to handle uncertainty is powerful and useful. Indeed, even if we do not know the exact model of a system to be controlled or if the model is complex, it is still worth utilizing a simplified version of the model.

2.3. Information load

For an online shopping site, a feedback control approach can adapt to individual differences by noting the individual's information load and comparing it to the desired load predetermined by the e-commerce vendor, to control the number of choices that are sent to the customer. For our purposes, information load was defined as the number of choices presented over a given period of time. Individual differences occur, creating varied thresholds of information load. For example, one person may be able to review three product options in a minute while someone