Library Progress International
Vol.44 No.3, Jul-Dec 2024: P.3117-3123

Print version ISSN 0970 1052
Online version ISSN 2320 317X

Original Article

Available online at www.bpasjournals.com

Machine Learning Evaluation of Key Aspects of User Preferences and Usability of E-Commerce Websites

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How to cite this article: Anand Pandey, Kamal Batta, Shaina Arora, Prithivi Raj, Shreya Chakraborthy, S. Kaliappan, (2024). Machine Learning Evaluation of Key Aspects of User Preferences and Usability of E-Commerce Websites. *Library Progress International*, 44(3), 3117-3123.

Abstract

This study explores the application of machine learning techniques to evaluate key aspects of user preferences and usability on e-commerce websites. As online shopping becomes increasingly prevalent, understanding user behavior and improving site usability are critical for enhancing customer satisfaction and driving sales. We employ various machine learning models to analyze user interaction data, including clickstreams, purchase history, and navigation patterns. The analysis focuses on identifying factors that influence user preferences, such as product recommendations, page load times, and user interface design. Additionally, usability metrics are assessed to determine their impact on the overall user experience. The findings highlight significant correlations between specific website features and user engagement levels, providing actionable insights for optimizing e-commerce platforms. By leveraging machine learning, this research offers a data-driven approach to enhancing user satisfaction and operational efficiency in the e-commerce industry.

Keywords: Machine learning, Online Shopping, Consumer Perception, Website Attributes, Data Driven

Introduction

One of the original purposes of the internet was to facilitate the global dissemination of various forms of information, such as research papers, statistics, photos, and videos. The web browser has established itself as the de facto standard for accessing data hosted on various web servers. The primary building block is a network of interconnected web pages, or hypertext[1]. Online shopping, corporate websites, B2B, commercial, educational, trading, publish/subscribe, and social networks are some of the most popular web applications, contributing to the ever-increasing Internet use. The millions of web sites that make up the WWW were created and launched by people from all over the globe. Every website serves a unique purpose and caters to a distinct community[2][3]. Websites are often classified into subcategories according to the services they provide, such as informational, commercial, and service websites. Web apps have advanced, but they have not yet reached maturity. An absence of knowledgeable engineers with experience in online software development and

the ability to build reliable, high-quality, complicated websites is the biggest gap. Audio, video, and 3D images, as well as text information, may be notoriously difficult to download. Reliability, usability, security, availability, scalability, maintainability, and time-to-market are additional concerns linked to the immaturity of online software development[4][5]. An effective website is one that "generates a certain level of satisfaction from its users" according to the definition. Loss of productivity and income may result from poorly designed websites. There are a lot of websites out there that still annoy people a lot. Applications related to electronic commerce have been receiving a lot of focus as of late. Internet usage for business reasons has increased in the 21st century due to technical advancements. After the first commercial website went up in 1994, e-commerce took off. The usage of online shopping is expected to skyrocket in the next years.[6] This emerging concept that involves the process of buying, selling, or exchanging products, services, and information over the Internet" is known as electronic commerce (E-Commerce). There are four distinct kinds of e-commerce websites: B2B, C2C, C2C, and C2B. Both types of websites connect businesses with consumers. Here is a description of them:

• B2B: In B2B, the transactions are done between the buyer and seller companies
• B2C: In B2C, the business organization transacts with a consumer . This retailing business is known as e-retailing .
• C2C: In C2C, one consumer sells directly to another consumer . The example of this type is online auction .
• C2B: In C2B, the business provides the product to consumers as per their requirements . The requirements are to be determined by the customers. This research focuses on usability and productivity of B2C e-commerce websites. Ecommerce provides several advantages to business organizations and to consumers[7] The advantages that e-commerce extends the marketplace of a business into national and international markets. So the business can have access to people across the globe . The e-commerce websites give some common benefits to customers, which are discussed below:
• From any position around the world, the customers perform their transactions at any time .
• Many online shopping service providers offer a variety of products for their customers with many choices . They provide the opportunity to the customers to perform and evaluation of product and services and comparison of prices globally[8].
• It also provides opportunity for online tracking, monitoring and progress of the delivery of the product.
In the digital age, e-commerce websites play a crucial role in retail, providing consumers with the convenience of shopping from anywhere at any time. As the competition in the online marketplace intensifies, understanding and meeting user preferences while ensuring optimal usability have become pivotal for the success of e-commerce platforms[9]. User satisfaction, influenced by a multitude of factors ranging from website design to the efficiency of product recommendations, directly impacts customer loyalty and conversion rates. Therefore, a comprehensive analysis of these elements is essential for e-commerce businesses aiming to stay competitive[10].
Machine learning offers powerful tools for analyzing vast amounts of user interaction data, uncovering patterns and insights that might be imperceptible through traditional analysis methods. By applying machine learning techniques, we can systematically evaluate and enhance various aspects of user experience on e-commerce websites[11]. These techniques enable the identification of key determinants of user preferences and usability, such as site navigation efficiency, product recommendation accuracy, and overall user interface design[12].
This study aims to utilize machine learning models to assess and improve the user experience on e-commerce websites. Specifically, we will analyze data from user interactions, including clickstreams, purchase history, and navigation patterns, to identify factors that significantly influence user satisfaction and engagement. By evaluating these factors, we seek to provide actionable insights that e-commerce businesses can implement to optimize their websites, thus enhancing user satisfaction and operational efficiency[14]. The remainder of this paper is structured as follows: we first review relevant literature on user preferences and usability in e-commerce, followed by a detailed description of the data collection and preprocessing methods. Next, we outline the machine learning models used and discuss the evaluation metrics for assessing website usability and user preferences. Finally, we present the results of our analysis, discuss the implications for e-commerce businesses, and suggest directions for future research[15].
A measure of productivity is said to be complete productivity if it takes into account all inputs and outputs. In order to calculate total productivity, we need the monetary values of inputs and outputs. One way to calculate the profit from a manufacturing process is to subtract the value of the inputs from the value of the outputs. It is the goal of any manufacturing process to maximise this metric, which measures the overall efficiency of the operation[16]. The three main types of productivity metrics used in the past have been direct, partial, and indirect measurements. It is not easy to assess total productivity in reality since it involves comparing all inputs and outputs, which is not possible because various

kinds of inputs and outputs cannot be directly combined. That is why it's usual to use incomplete productivity measurements[17]. You may get the partial productivity ratio by dividing the entire output by either all of the inputs or just a portion of them. When evaluating the results of investments in information technology, one typical metric to employ is labour productivity. Divide the entire output (the number of items, for example) by the labour input (the number of man-hours), and you get the labour productivity ratio[18]. In addition, when the data required for partial productivity measurements is unavailable, indirect productivity measurement may be used. The core tenet of indirect productivity measurements is the hypothesis that certain events or symptoms are associated with productivity problems. High rates of faults and machine malfunctions, empty capacity, excessive material scrap, needless transportation, unpleasant working conditions, and lengthy wait times are all examples of such issues. These variables are the focus of indirect productivity measurements because they are both directly and indirectly connected to productivity and because they may help to explain why productivity has changed[19]. In addition, due to changes in business processes and indirect consequences, it may be difficult to quantify the benefits of e-commerce services on productivity using these conventional metrics. On the other hand, we suggested a single service metric that takes into account the one output and several input criteria to calculate the productivity on e-commerce websites as shown in figure 1

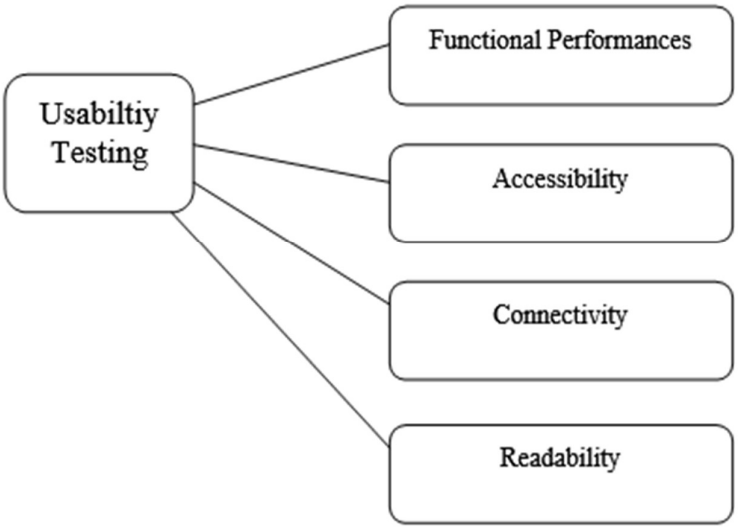

Figure 1. Model for Usability Testing of E-commerce Applications

II. RELEVANT USABILITY CRITERIA

Usability is accepted as the industry standard for modeling website which has been significantly referred by researchers, scientists as well as software experts. Usability testing is based on several and somewhat subjective features. One of its important features is that it is determined entirely by the client or end user which depends on upon the person's ability to assess their entire client encounter. The quality that a client encounters is ascertained on his/her ability to use and utilize the company's product and services. For example, at each purchase, one from an impact depending on how it was sold, how it was provided, how it's performed, how well it was reinforced etc[1][7]. Presently the market of the complex computer system is saturated with competing brands. This has made usability more general and largely widespread in some years Apropos the demands, manufacturers are started making the products user-friendly rather than technology friendly[10]. The usability professionals can provide an understanding and discovering the relationships between user and product and also provide an understanding that is impossible by market research . In the view of web development, usability is one of the important criteria. s. Normally the users don't want to wait and learn how to use a home page. There's no such thing as a training class or a guide for a website. Users should be able to understand and navigate the

website soon after checking the homepage for a couple of minutes." Most informal customers just leave the site and surf or shop somewhere else. In this section, we present a few essential usability features. Some of the Usability features are presented here and other aspects are detailed in the rest of the work[19]. Usability can be analyzed by the person's experience in getting content or services. Initially, a person's experience aims at application and application growth. Functionality also refers to web design and is further analyzed in conditions of

How quickly can a client who has never seen the interface get up and running and complete critical tasks? This is the ease of learning aspect.

Usability: How long does it take for a well-informed consumer to get their hands on things once they've mastered the design?

Recall: Can a client who has used the design before still use it successfully, or does he or she need to start learning all over again?

How often are mistakes made by users and how easy is it for them to fix them? This is the frequency and severity of errors.

III. DESIGN FOR USABILITY

Any system which is intended to make for individuals ought to be handy to utilize, to learn and memorize. A few researchers suggest that developers striving for usability adhere to three outline standards

• Early concentrate on customers and tasks • Empirical measurement

• Iterative design Early concentrate on customers and tasks The design group ought to be user driven and can immediately contact potential customers. A few assessment methodologies, such as intellectual modeling, examination, query, and prototyping are used to study potential users. In view of usability, who the customers are and their involvement with systems must be analyzed. To understand users, this knowledge must be used for the tasks that the users are expected to perform[18] . This incorporates the investigation of what tasks the customers will perform, which are most critical, and what choices the customers will make while utilizing the system. It is required that the designers should analyze the cognitive and emotional characteristics of users which can be related to a proposed system. Empirical measurement This study can be done at the preliminary stage taking real users to concern for using behavioral measurements[9]. This incorporates testing the system for both learnability and its easy usage. It is essential at this stage to utilize quantitative ease of using details, for example, time and mistakes to perform and finish tasks, a number of customers to evaluate, analyze the efficiency and mentalities of the customers evaluating the system [99]. Lastly, the focus on empirical measurement is on measuring both formal and informal tasks, which can be performed through a wide range of assessment methodologies[11].

Iterative design It is a design strategy taking into account a cyclic procedure of prototyping, examining, and refining an item or procedure. Considering the testing of the latest cycle of a design, improvements and changes are made. This system is improvised to make sure that in due course of time the quality and performance of a design is enhanced. In this design, interaction is done as a form of a research tool for informing and evolving a project, as successive versions. The Chief features of Iterative Design are to recognize the required changes, strength to make changes and a desire to make changes. At any stage of difficulties, no such methodologies are applied to get the right solution. Under this circumstance, a user can try empirical methods in the process of using system development and makes sure it is more appropriately done within few minutes. By trying this technique iterative design becomes compatible meeting goals such as making the system comfortable to use [99].

IV. INSPECTION METHODOLOGIES

This technique facilitates perceiving the customers by an experimenter or by a special analyst to examine and assess an assigned system. They provide more quantitative information as assignments can be timed and documented. Some of the inspection methodologies discussed below: Card sorts Card sorting is an approach that includes customers to gather data for a site's usability survey. Users in a card sorting session are requested to organize the content from a web page in a way that sounds good to them. Users make a necessary survey on products from a web page and group them into categories[19]. This technique figures out how customers consider the content and organize the data on the website. This technique makes the customers ignorant of the structure for a web page and who blindly decide to put something on the homepage. Ultimately, customers are guaranteed to have an organized data on the site

This research technique deals with anthropological study or survey. Here, the user gathers and studies field findings that define an artistic outlook of a work, for example, Post-it notices, products on the desktop, shortcuts, and items in trash bins. This procedure also ensures the best outcomes by gathering the information in the sequence of work and number of

interruptions that determine the particular day of a user Heuristic Assessment Heuristic assessment is used for engineering methodologies to explore and assess usability issues in a user interface design as a part of an iterative design. Further, it involves a small team of evaluators and analyzes the user interface by using recognized usability principles (the "heuristics") . The use of this technique has become scanty nowadays as it is costly and full of complexities. This assessment has been helpful in the computer user interface design. The set of principles is categorized by the usability professionals to find relevant issues in this technique (heuristics). These ten general standards are used for interface design. The term "heuristics" is applied here to find the relevance in the line of dependable guidelines, not with particular usability rules These heuristic methods are described below:

• The permeability of framework status: The customers need to be informed and alert about the progress of the work within the framework and the stipulated sensible time frame.

• Coordination between the program and the actual world: The customer's dialect is to be framed with words, expressions and ideas known to the customer, not by the system oriented conditions. A genuine request has to be made as per the real world demand to make sure that the important characteristics of the website are highlighted.

• User control and flexibility: The users are allowed to make an emergency exit from a website if they confront erroneous information without wasting much time on the prolonged conversation.

Consistency and models: Users need not bother whether distinctive words, circumstances or activities are meaning the same.

• Mistake counteractive action: Initially error information cautious and does not allow issues to happen in the first place. It is better if customers are made alert and verified before entering into error prone circumstances.

• Recognition rather than recall: The customer's memory load is reduced by error free items, activities, and choices. It is not required for the customers to recollect data starting with one piece of dialogue than to the next. It is advisable that for the utilization of the framework a noticeable and effortless attempt can be made or whatever seems appropriate[20].

• Flexibility and performance of use: This technique is required to be handy and flexible for both novice and old users.

• Aesthetic and simple design: It would be appreciated if the website is designed with artistic fervor and a simple look.

• Offer customers some assistance with recognizing, analyzing, and restoring from errors: Error information need to be indicated in simple terminology, accurately provides issues and successfully recommends a remedy.

• Help and documentation: The framework can be designed without documentation to assists the users. While searching for an unknown information, the website needs to be user-friendly in order to accumulate data easily but not by grouping in the dark

V. WEBSITE NAVIGATION AND CONTENT

The term "navigation" describes the steps used to move around a hypertext-based network of websites on the Internet [63]. The user's ability to access the site is the only thing that the web browser really does. One of the most important aspects of web design that improves usability is the creation of a user-friendly navigation interface. Improving the usability of the web's navigation interface is a major focus in web design. Worldwide, neighbourhood, supplementary, and relevant routes are all vital components of a site's overall navigational scheme; they make up the larger subject of online navigation[21]. Since it is the fundamental navigational framework, another framework known as hierarchical navigational frameworks is also vital and must be considered indispensable. Although it takes into account the user navigating the website just via levels, many find this approach limiting and see the need for additional navigation frameworks to improve the site's structure. While local navigation is often utilised to assist users within a specific section of a website, global navigation acts as a blueprint and template for the ultimate goal of achieving a simple click for users accessing the web page[4][9][10]. To further improve and enhance the user experience when working on a website page, all of these navigational tools are further categorised in a separate list of web navigation. In The usage of online navigation is on the rise, not only on desktop computers but increasingly on mobile devices like smartphones and tablets. Recent innovations, such as the introduction and development of smartphones, have impacted online navigation. A growing percentage of American adults (68% as of December 2014) have access to advanced cells. Web navigation techniques, which were formerly limited in usage, are now used on a daily basis by people all over the globe due to their rising popularity..

Machine learning can be highly beneficial for evaluating key aspects of user preferences and usability of e-commerce websites:

Product RecommendationsPersonalised product suggestions may be generated by analyzing client data such as browsing history, purchasing behavior, and preferences using machine learning algorithms. Both the consumer experience and conversion rates are enhanced by this.

Search Optimization: Machine learning can enhance site search by understanding natural language, predicting user intent, and providing relevant autocomplete suggestions. This streamlines the shopping journey and reduces zero-result searches.

Pricing Optimization: ML can dynamically adjust pricing based on factors like demand, competition, and customer segments to maximize revenue and profit margins.

Fraud Detection: Machine learning models can identify fraudulent activity and protect customer data by detecting anomalies in purchasing patterns.Customer Segmentation: ML enables advanced customer segmentation to deliver tailored marketing campaigns and offers that resonate with different user groups.

Chatbots and Automated Support: AI-powered chatbots can provide 24/7 customer service and support, improving satisfaction by quickly addressing inquiries.

VI. PRODUCTIVITY EVALUATION USING USER'S PERCEPTION

Productivity is often thought of as a mean indicator of how efficient a manufacturing system is. It is the product's output divided by the product's inputs, or the product's output per unit of input. Services or goods are what come out of it. Generally speaking, there are three main ways to quantify productivity: total, partial, and indirect. Productivity may be defined as the ratio of an activity's net output to its total inputs. Though it provides a more precise picture, summarising and directly comparing the many forms of output and inputs is challenging. Furthermore, it does not account for the interplay between the output and any one input in isolation. Further, when just one kind of input is considered, the resulting output is known as partial productivity. One form of productivity indicator that is relevant here is labour productivity, which is defined as the ratio of total output to labour input. Partial productivity measures can have important instances, such as capital and material productivity[6][8]. This metric for productivity is straightforward in terms of both its meaning and the data needed to calculate its indices. An alternative to partial productivity measurements is the indirect productivity measurement, which may be used in cases when the necessary data is not available. Indirect measures of productivity look for specific symptoms of problems. In this context, these symptoms or phenomena might take the form of machine problems, excessively lengthy waiting times, a high failure rate, or underutilised capacity. Indirect productivity indicators focus on these issue signs. The variations in productivity are caused by indirect productivity metrics, which are connected to productivity. When evaluating the return on investment (ROI) of information technology (IT) projects, labour productivity is often used as a proxy for indirect productivity. The relationship between usability and ROI is straightforward. The return on investment (ROI) measures how much of an economic benefit an investment yields in terms of increased output or profit. A positive return on investment (ROI) occurs when the cost of the investment is less than the benefit. Customers will be more satisfied, fewer will need to contact customer support, and revenues will skyrocket if a website's usability has been much enhanced[10][11]. Reducing the time to perform a job, boosting satisfaction, and lowering the mistake rate are all ways in which usability enhancement directly influences growing productivity. Time saved, money earned, and productivity gains are the most common metrics used to quantify these advantages.

VII. Conclusion

The application of machine learning models provided deep insights into user behavior, revealing patterns that traditional analysis methods might overlook. These insights can guide e-commerce businesses in making data-driven decisions to improve website usability and cater to user preferences more effectively. For instance, enhancing site navigation efficiency and ensuring personalized product recommendations were found to be crucial for increasing user engagement and satisfaction. Moreover, this study demonstrated that machine learning is a powerful tool for continuous improvement in the dynamic landscape of e-commerce. By regularly analyzing updated interaction data, businesses can stay attuned to evolving user preferences and rapidly implement changes to meet user needs. This adaptability is essential for maintaining competitiveness in the fast-paced e-commerce environment. This work research highlights the significant benefits of integrating machine learning into the evaluation and optimization of e-commerce websites. The insights gained from this approach not only enhance user satisfaction but also drive higher conversion rates and customer loyalty.

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