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Development of a Fuzzy Logic model for Online Shopping Support

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Abstract
Customer support has always been crucial to electronic commerce. Traditionally provided over the phone, it has recently expanded to include various alternative communication channels su ch as email, social networks, forums/message boards, live chat, and self-serve knowledge bases. As a result, maintaining high-quality customer support across these growing channels has become increasingly costly for e-commerce businesses. They must hire individuals with strong language and communication skills, and each new employee requires multiple training sessions to operate effectively in a specific channel. This process is inefficient, time-consuming, and makes it challenging to ensure round-the-clock customer support year-round. To address these challenges, this research has developed an automated customer support system for online shopping using fuzzy logic. The developed system was evaluated based on precision, recall, specificity, and balanced accuracy. The results indicate that these metrics improve as the number of prospective customers grows. This demonstrates that the system's performance enhances as the volume of prospective customers increases.

Keywords: ***Electronic commerce, Fuzzy logic, Customer satisfaction, Online Business, Fuzzification***

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I. INTRODUCTION

As technology continues to evolve rapidly, electronic commerce has increasingly taken the place of traditional retail methods. This shift has allowed businesses to leverage the Internet to reach a larger audience easily. Companies can now market and sell their products online, a practice widely known as e-commerce, or alternatively referred to as online retailing, online shopping, or Internet shopping.

E-commerce essentially involves conducting business over interconnected networks, primarily the Internet. It encompasses the sale of goods and services through various technologies, including mobile commerce, electronic funds transfer, supply chain management, and online transaction processing. One significant advantage of online shopping is its time efficiency, which is crucial for today's busy individuals who often prefer not to spend much time shopping. In contrast to traditional shopping, where there are limitations, online shopping offers greater flexibility. Consumers can easily compare prices across different platforms, which is particularly appealing in countries like Nigeria, where price sensitivity is common.

The aim of e-commerce is to replicate and enhance the negotiation processes typically conducted between people. However, the complexities of human interactions are challenging to capture fully, which is why many current e-commerce platforms serve primarily as catalogs featuring product descriptions and prices. There is a growing need for digital agents to navigate the Internet, gather information, perform tasks on behalf of users, and deliver the results efficiently.

Online shopping has become a prominent term in the business landscape, widely recognized in both developing and developed countries. In Nigeria, the last five years have seen rapid growth in online shopping, with platforms like Jumia, Konga, and jiji emerging. The past decade has brought significant changes in consumer shopping habits; while physical stores remain popular, many consumers now prefer the convenience of online shopping, which saves time and effort. Customers can easily compare products from home, accessing a wide variety of options. The online business sector is leading in the use of innovative Internet technologies to enhance market services. Online retailing has transformed traditional business practices, providing a highly productive medium that major retailers are eager to utilize for competitive advantage. As a result, customer shopping behaviors have evolved dramatically, embracing the online model.

However, one significant challenge for many companies is maintaining customer satisfaction and service quality. As businesses grow, they face the task of tracking customer information, documenting interactions, and providing prompt, personalized support. Poor customer service can lead to loss of clientele, making it essential to prioritize customer satisfaction both before and after transactions. In a competitive market, attracting new customers is resource-intensive, making customer retention and relationship-building critical. Unfortunately, many online shoppers report dissatisfaction with service quality. This research aims to proffer solution to the above challenges by developing a Fuzzy Logic model for Online Shopping Support

Fuzzy logic is a versatile technique used to address a broad spectrum of industrial control and information processing applications. It has become a valuable tool for handling decisions involving uncertainty, imprecision, partial truths, or qualitative decision-making challenges, aiming to achieve robustness, simplicity, and cost-effectiveness. However, it lacks the ability to automatically generate the rules it applies in the decision-making process [1]. The advantages of these systems over conventional production rule based expert systems may be characterized as follows: fuzzy sets symbolize natural language terms used by experts; since the expert knowledge captured in "If.… Then" statements are often not naturally true or false, fuzzy sets afford representation of the knowledge in a smaller number of rules; and smooth mapping can be obtained between input and output data [2].

II. Literature Review

[3] in their study "Post-purchase Shipping and Customer Service Experiences in Online Shopping and Their Impact on Customer Satisfaction," examined how post-purchase activities affect customer satisfaction in online shopping, as well as how this satisfaction influences future purchasing intentions in China and Taiwan. The research aimed to clarify the role of post purchase logistics—such as shipping, returns, and tracking—in shaping customer satisfaction and purchasing decisions, while also highlighting differences between the two regions. A validated survey was conducted, collecting responses from 384 participants in China and 145 in Taiwan. The analysis utilized a component-based estimation approach in structural equation modeling. This work expanded the concept of customer satisfaction beyond just purchase activities, establishing a model that includes determinants of e-commerce satisfaction linked to post-purchase logistics. However, the study was limited by its inability to examine changes in customers' purchase intentions over time.

[4] in "Towards Automated Customer Support," investigated automating customer support on Twitter. The study was driven by the need for companies to maintain highquality support across multiple channels. The objective was to enhance a manually defined rulebased algorithm currently used by a large telecom company through machine learning. The research utilized a dataset of over two million posts from Twitter customer support. It employed specialized tokenization for data preprocessing and implemented two types of models: retrieval based (using BM25) and generative neural networks (seq2seq with attention and Transformer). The findings indicated that generative models outperformed retrieval-based models but faced challenges when training data was limited for specific topics. A limitation of this research was the system's inability to address questions with answers that change over time, such as those related to service updates or new product launches.

[5] in "The Customer Support Service Development for User Applications" focused on the development of user support services for client applications. Their goal was to understand the analytical and planning processes involved in creating a user support bot. A bot is designed to mimic human interaction, automating tasks such as responding to messages and providing information. The study aimed to develop a customer support service for user applications, specifically by analyzing Telegram's capabilities for handling files and messages, as well as the mechanisms available for bot development. They also examined GLPI's internal structure and its API for building a Ticket Service. The research led to the creation of a Web API application using ASP.NET Core, tailored for RESTful interactions. However, the study had limitations, such as the inability for users to attach files of various formats to tickets and a lack of file storage options in the system.

[6] in "Online Shopping and Customers' Satisfaction in Lagos State, Nigeria," assessed customer awareness of online shopping and explored the relationship between online shopping and customer satisfaction. Motivated by the need to understand factors influencing customer satisfaction in Nigeria, the study aimed to identify and analyze aspects that encourage customers to shop online. Specific objectives included measuring customer awareness of online shopping and its benefits, determining factors driving online shopping usage, assessing customer satisfaction levels, and understanding how online shopping affects overall satisfaction. The research was limited to the Lagos metropolitan area and employed purposive and convenience sampling methods to select respondents who could provide valuable insights. The sample size was calculated to estimate a proportion from an infinite population with a 95% confidence level, but the study was confined to Lagos.

[7] in "The Impact of E-Service Quality and Customer Satisfaction on Customer Behavior in Online Shopping," sought to enhance understanding of key dimensions of e-service quality that affect customer satisfaction, trust, and behavior. This research aimed to address e service quality challenges and tested a hierarchical model of e-service quality in a new cultural context, comparing perceptions between Indonesia and

the USA. Targeted respondents were selected based on specific criteria to ensure relevant information was gathered. The research utilized partial least squares (PLS) path modeling in Smart PLS software to evaluate validity and reliability, assessing metrics like composite reliability, factor loading, and average variance extracted for convergent validity. However, a limitation of this study was its inability to account for a range of product segments or industries to ensure that the measurement applied consistently across different contexts.

III. Methodology

The architecture of the system shows step to step and this can be depicted in the figure 1 below. The descriptions of the various components that make up the system are also presented.

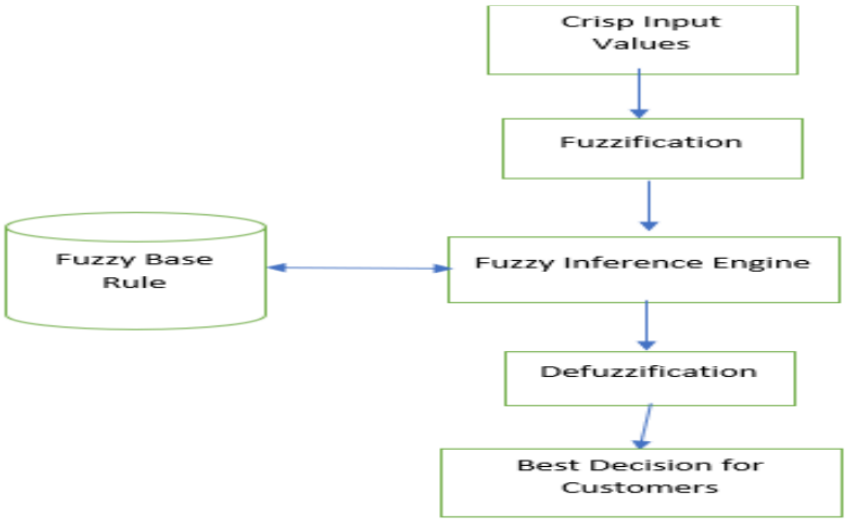

Figure 1: Architectural design of the system

The research work makes use of Frequently Ask Questions (FAQs), quantitative study of the online shopping user's experiences in Nigeria and datasets from online (www.kaggle.com) to form the dataset to be used in this research work. A customized database was developed to manage all customer records effectively. In this universal table, redundant entries were removed, and any incomplete records were excluded to ensure the database is suitable for applying the recommender algorithm. The fuzzy set of input dataset will be in form of High, Medium and Low. The following crisp set of input data will be gathered and converted to a fuzzy set using fuzzy linguistic variables and fuzzy linguistic terms, through the process of fuzzification. The research work will construct a membership function for the crisp sets. Linguistic variables are inputs and output variables in the form of simple words or sentences in which each QAS will be decoded, such that, Product Satisfaction will be PS, Live Chat Satisfaction will be LCS, Product Quality Rating will be PQR, Response Time will be RT, Reasonable Price will be RP, Accessibility will be AC, Empathy will be EM and Convenience will be CO.
Gaussian Membership Function was used for the generalization of the indicator function to represent the degree of truth as an extension of valuation. The Gaussian membership function is represented using equation 1 as follows.

(1)

where c represents centre, s represents width and represents fuzzification factor.

The system will made use of six inputs and a single output. The inputs are deduced from the response that will be fed into the system. The inputs are represented as and . The if-then rules for the first order Sugeno fuzzy model is given as:

Rule 1: If is and is then = (2)
Rule 2: If is and is then = (3)
Rule 3: If is and is then = (4)
Rule 4: If is and is then = (5)
Rule 5: If is and is then = (6)

where and are the questions to input into the system; , are the potential response to the customer's request , , …… and … are constants and is the output which is the best customer support response.

The next stage is the defuzzification process. The defuzzification process is done by the defuzzifier to translate the output of the inference engine into crisp values which is mostly required for proper analysis and interpretation. This interface receives as input, the output of the inference engine which is a fuzzy set. The defuzzification process will be calculated by automatically loading the data and rules into the system.

(7)

where is the result of the extraction process of the weight of membership, *z* the output value of each rule, while represents the defuzzified output value which is the best decision support to customers based on their requests.

IV. RESULT AND DISCUSSION

The research work was evaluated using customer feedback, precision, accuracy and response time. The Customer-side/interface pages (front-end) will be designed using "Bootstrap 3" front-end framework that contains HTML5, CSS3 and JavaScript. For the back end, PHP will be used to implement the Fuzzy Logic while MySQL will be used for working memory functional database. A feedback option was provided on the developed system for the customers who have used the system and got an automatic support system to gauge the performance of the developed system. A total of 400 feedback from prospective customers, based on which the research work has evaluated the system with respect to five performance metrics: precision, recall, F1 score, specificity, and balanced accuracy.

Table 1: Confusion Matrix for 400 prospective customers

Confusion matrix	Positive ratings given by customers (rating ≥ 3)	Negative ratings given by customers (rating < 3)
Positive ratings recommended By the developed system (rating ≥ 3)	True positive, TP (321)	False positive, FP (41)
Negative ratings recommended by the developed system (rating < 3)	False negative, FN (10)	True negative, TN (28)

a. Precision

= = 0.887 = 88.7% (8)

b. == 0.97= 97% (9)

c. = = = 0.916 = 91.6% (10)

d. = = = = 0.471 = 47.1% (11)

e. = = = 0.704= 70.4% (12)

Table 2: Summary of the performance metrics

Metrics	Number of Prospective customers	Number of Prospective customers	Number of Prospective customers	Number of Prospective customers
	100	200	300	400
Precision (%)	81.9	84.1	86.2	88.7
Recall (%)	90.7	92.5	92.8	97
F1 Score (%)	86.1	88.1	89.4	91.6
	32	33.0	44.4	47.1
Balance Accuracy (%)	61.4	62.5	68.6	70.4

The result in table 2 above shows that the precision, recall, specificity and balance accuracy of the system increases as the number of prospective users increase. This shows the developed system recorded good performance as the number of prospective customers increase.

IV. CONCLUSION

The system was built as a website using HTML, JavaScript, CSS, and Python (for the fuzzy logic component). Its performance was assessed using precision, recall, specificity, and balanced accuracy. The results indicate that as the number of prospective customers increases, the system's precision, recall, specificity, and balanced accuracy also improve. This demonstrates the system's strong performance with an increasing number of prospective customers.

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