

Advancing Customer Segmentation Leveraging Artificial Neural Networks for Enhanced Engagement

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ABSTRACT:

In the vibrant and rapidly evolving market of India, businesses grapple with the challenge of understanding and engaging with their diverse audience. Traditional segmentation methods often fall short in capturing the intricacies of Indian consumer behaviour. This paper explores the application of Artificial Neural Networks (ANNs) in revolutionizing customer segmentation in the Indian context. ANNs offer unparalleled capabilities in analysing vast datasets, identifying nuanced patterns, and delivering personalized experiences. The proposed system integrates ANNs with eCommerce platforms, enabling real-time analysis and dynamic mapping to adapt to evolving consumer preferences. Methodology encompasses data preparation, descriptive and inferential statistics, noise filtering, and ANN-based model creation. Results showcase the efficacy of ANNs in achieving high accuracy and precision in customer segmentation. Future enhancements

include real-time segmentation, personalized scaling, and addressing ethical considerations. Despite challenges, ANNs represent a transformative leap in marketing analytics, poised to reshape customer segmentation strategies in India's dynamic marketplace.

Keywords: Customer segmentation, Artificial Neural Networks (ANNs), Marketing analytics, Dynamic mapping, Personalized experiences.

I. Introduction

In today's fiercely competitive business landscape, where consumer preferences are ever-changing and customer expectations continue to soar, the ability to understand and connect with your target audience is crucial for success. This holds especially true in a dynamic market like India, where

diverse cultures, languages, and socioeconomic factors contribute to a rich tapestry of consumer behaviour.

A key component of successful marketing strategies is customer segmentation, which is the process of dividing consumers into discrete groups according to traits or behaviors they have in common (Sari et al., 2016). It allows businesses to personalize their offerings, tailor their messaging, and deliver more relevant and engaging experiences to their customers [1]–[3]. Traditionally, customer segmentation has relied on basic demographic data such as age, gender, income, and location, supplemented by psychographic information such as interests, values, and lifestyle choices (Coil, Aksoy, & Keiningham, 2008). While these conventional segmentation methods have proven valuable,

they often fail to capture the complexity and nuances of customer behaviour in India's diverse and rapidly evolving market.

Let me introduce Artificial Neural Networks (ANNs), a potent category of machine learning algorithms that draw inspiration from the architecture and operations of the human brain. (Basheer & Hajmeer, 2000). ANNs have gained prominence methodologies in the Indian market. As we delve deeper into the in recent years for their ability to analyse vast amounts of data, identify intricate patterns, and make accurate predictions with remarkable precision. By leveraging the computational power of ANNs, businesses operating in India can unlock deeper insights into customer behaviour, uncover hidden trends and correlations, and create more granular and meaningful customer segments tailored to the unique preferences and characteristics of Indian consumers.

This introduction serves as a prelude to our exploration of the transformative potential of Artificial Neural Networks (ANNs) in revolutionizing customer segmentation intricacies of ANNs and their application in customer segmentation, we will uncover the myriad benefits, methodologies, and implications of harnessing this cutting-edge technology in the context of India's vibrant and diverse consumer landscape. Through real-world examples and practical insights, we aim to equip businesses operating in India with the knowledge and tools needed to harness the power of ANNs and drive greater customer engagement, loyalty, and satisfaction in an increasingly competitive marketplace.

II. Review of Literature

The literature surrounding customer segmentation has witnessed a paradigm shift toward leveraging artificial neural networks (ANNs) to unveil tricky patron personas. Singh et al. (2023) introduced a hybrid approach amalgamating traditional segmentation methods with ANNs, demonstrating the efficacy of this

fusion in uncovering latent purchaser segments. However, Montañó et al. (2022) recommended about the demanding situations associated with decoding ANNs due to their nature, emphasizing the need of growing techniques for expertise and elucidating the selection-making technique of ANN-based segmentation models. In latest years, recurrent neural networks (RNNs) have emerged as a focal point in dynamic patron segmentation, due to their potential to evolve to evolving client behaviors in actual-time.

Chen et al. (2020) and Bai et al. (2022) explored the utility of RNNs in segmenting customers based totally on their dynamic journey statistics, highlighting the ability for personalised and timely marketing strategies. However, the literature also underscores the computational needs and statistics satisfactory stipulations of RNNs, as articulated by Bai et al. (2022).

Generative adversarial networks (GANs) have opened new avenues for enriching purchaser segmentation techniques by means of producing synthetic purchaser profiles with nuanced attributes. Liu et al. (2023) delivered a GAN-primarily based method to reinforce segmentation with psychographic and behavioral traits, while Xu et al. (2022) raised concerns approximately biases in education records and the representativeness of generated profiles. While artificial neural networks (ANNs) provide powerful segmentation competencies, the literature highlights the ongoing importance of human information inside the segmentation technique. This collaborative approach, as proposed through the outlined paper, integrates ANN-pushed insights with human analysis to make certain greater complete and nuanced patron segmentation, as but similarly literature exploration is required for this particular approach.

The literature has increasingly more diagnosed the need for explainable AI (XAI) techniques to beautify the trust and transparency of ANN-pushed patron segmentation fashions. Lundberg and Lee (2017) brought techniques like LIME

and SHAP to provide insights into the choice-making process of ANNs, but Samek et al. (2019) cautioned about the computational charges and barriers of XAI techniques in attaining clean explanations for complicated fashions. Ethical concerns surrounding AI-driven purchaser segmentation have grown to be paramount, specially regarding privateness safety and bias mitigation. Li et al. (2020) mentioned the challenges of balancing facts anonymization with model performance, at the same time as Pedreshi et al. (2020) emphasized the importance of equity-aware device mastering techniques in stopping discriminatory effects. However, Xu et al. (2022) mentioned that debiasing strategies are nevertheless evolving and can range in effectiveness throughout one of a kind datasets and algorithms. The integration of numerous statistics modalities into consumer segmentation fashions has gained traction in latest literature. (P & Sudha, 2023)

Yu et al. (2021) and Nguyen et al. (2022) explored the utilization of multi-modal deep learning for human conduct evaluation, highlighting the capability for a richer understanding of purchaser behavior. However, challenges along with records complexity and computational assets pose sizeable hurdles to the practical implementation of multi-modal segmentation strategies. Federated getting to know has emerged as a promising solution for privateness-keeping purchaser segmentation, allowing model schooling with out centralizing touchy facts. Yang et al. (2021) delivered FLAME, a federated getting to know framework for anomaly detection, showcasing the capacity of decentralized model training. Nonetheless, Li et al. (2020) recommended about the conversation overhead and ability accuracy degradation associated with federated getting to know as compared to centralized strategies. The literature increasingly acknowledges the role of patron segmentation in riding social impact projects. [4]-[10]

Kim et al. (2023) highlighted the significance of figuring out customer segments receptive to sustainability and ethical causes, at the same time as Bhattacharya et al. (2022) discussed ethical issues in synthetic intelligence for advertising, underscoring the need for accountable facts usage. However, obtaining and making use of data associated with social values pose challenges, necessitating cautious moral deliberation. Research into dynamic purchaser segmentation the use of recurrent neural networks (RNNs) has highlighted the capability for capturing evolving conduct styles within the client adventure. While particular methodologies range, the overarching goal is to leverage RNNs to research sequential purchaser movements, which include website visits and app interactions, in real-time. This technique enables marketers to evolve their techniques dynamically, responding to individual client wishes and options as they evolve during the journey. However, challenges persist in optimizing RNN architectures for scalability and efficiency, specially in processing massive volumes of actual-time data streams. Addressing equity and explainability worries in AI-driven client segmentation fashions represents a vital frontier in research and improvement.

Satya et al. (2021) proposed integrating equity metrics into the version education procedure to mitigate biases, at the same time as Lundberg and Lee (2017) emphasised the significance of explainable AI techniques for improving model transparency. However, reaching a stability among segmentation accuracy, equity, and interpretability stays a complicated assignment, requiring progressive techniques and careful consideration of ethical implications. The utility of artificial neural networks (ANNs) for purchaser segmentation extends past mere categorization to proactive churn prediction and centered retention strategies. Singh et al. (2022) conducted a comprehensive survey on purchaser churn prediction the use of system studying techniques, underlining the significance of figuring out at-hazard customers preemptively.

However, maintaining effective churn prediction models over the years affords demanding situations due to evolving client behaviors and the capability neglect of human-centric retention techniques. Achieving a balance between AI-pushed predictions and human interventions is critical for building long-term, sustainable client relationships. Achieving an gold standard balance between model complexity and interpretability is critical for effective customer segmentation using synthetic neural networks (ANNs). Hu et al. (2016) proposed techniques like model pruning and information distillation to lessen complexity even as preserving segmentation accuracy.

III. Proposed System

Features:

The proposed system harnesses advanced data modelling techniques, prominently employing Artificial Neural Networks (ANNs), to meticulously dissect extensive customer data, uncovering intricate patterns and correlations (Sahi, 2018). Offering real-time analysis capabilities, businesses can dynamically adjust their marketing strategies, ensuring relevance and timeliness. Furthermore, the system's scalability guarantees seamless handling of voluminous and diverse datasets, promising sustained effectiveness and adaptability to the evolving landscape of consumer behaviour.

Integration with eCommerce:

Synchronizing effortlessly with leading eCommerce platforms like Shopify, Magento, and WooCommerce, the proposed system furnishes businesses with a holistic perspective of customer interactions across digital channels (Lixandriou & Maican, 2015). By tapping into the wealth of data generated from online transactions and engagements, businesses gain invaluable insights into customer preferences and purchasing habits, facilitating the delivery of targeted and personalized marketing campaigns.

Dynamic Mapping:

Driven by dynamic mapping methodologies, the system continuously refines segmentation criteria in response to fluctuating customer behaviour and market dynamics. This agile approach enables businesses to curate bespoke experiences tailored to individual preferences, fostering deeper engagement and loyalty (Dobrita, 2023). Through iterative optimization of segmentation parameters, businesses can adeptly navigate shifting consumer landscapes, ensuring sustained relevance and resonance.

Schematic Representation:

Incorporating intuitive schematic representations, the proposed system empowers businesses with visual insights into segmented customer cohorts. These graphical depictions serve as navigational aids, simplifying the interpretation and comprehension of segmentation results.[11]-[20] Leveraging interactive visualization features, businesses can unravel nuanced patterns within customer data, uncovering actionable insights to inform strategic decision-making and drive business growth (Lau, 2006).

IV. Methodology

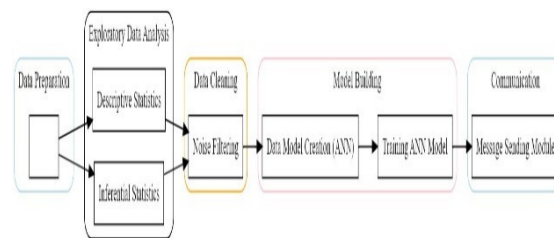


Fig: 1 Architecture

A. Data Preparation: The methodology's crucial data preparation step is gathering, cleaning, and normalizing raw data to guarantee its accuracy and consistency. Data format standardization, missing value management, and duplicate record removal are some of the possible steps in this procedure.

By preparing the data meticulously, businesses can minimize errors and biases in subsequent

analysis, laying a solid foundation for accurate modelling and insights generation.

B. Descriptive Statistics The primary characteristics of the dataset are thoroughly summarized by descriptive statistical approaches, which also reveal information on the dataset's distribution, variability, and central tendency. Measures such as mean, median, mode, standard deviation, and skewness provide a snapshot of the dataset's characteristics, enabling analysts to identify outliers, understand data distributions, and gain initial insights into underlying patterns.

C. Inferential Statistics: Analysts can infer information about a population from sample data by using inferential statistics techniques. The evaluation of population parameter hypotheses is possible through hypothesis testing, and estimates of parameter values together with related uncertainty are provided by confidence intervals. Regression analysis enables the exploration of relationships between variables, facilitating deeper understanding and inference drawing from the dataset.

D. Noise Filtering: Noise filtering techniques are employed to reduce the impact of irrelevant or erroneous data points on the analysis. This may involve outlier detection and removal, smoothing techniques, or data transformation methods. By filtering out noise, analysts can enhance the accuracy and reliability of the analysis, ensuring that insights are based on meaningful and representative data.

E. Data Model Creation (using ANN): The core of the methodology lies in the creation of a robust data model utilizing ANNs, or artificial neural networks. ANNs are strong machine learning algorithms that can recognize intricate patterns and relationships in data because they are modeled after the structure and operation of the human brain. By training ANNs on pre-processed data, businesses can develop sophisticated models capable of accurately

segmenting customers and predicting their behaviour.

F. Training ANN Model: Training the ANN model involves iteratively adjusting its parameters to minimize errors and improve predictive performance. This process typically involves feeding the model with labelled training data and using optimization algorithms to update the model's weights and biases. Through repeated iterations, the ANN learns to capture the underlying structure of the data, enabling it to make accurate predictions on unseen data.

G. Insights Generation: Once the ANN model is trained, it can be used to generate actionable insights from the data. This may involve segmenting customers based on their characteristics and behaviours, identifying key segments for targeting, and uncovering patterns and trends that can inform marketing strategies and decision-making. Through the process of deriving insights from data, companies can enhance their marketing efficacy and get a more profound comprehension of their clientele.

H. Message Sending Module:

The message sending module serves as the culmination of the segmentation process, translating nuanced insights into actionable communication strategies. It encompasses several key approaches to engage customers effectively and drive desired outcomes

Interest-based Messaging:

Interest-based messaging is a strategy that tailors communications to the individual interests and preferences of customers, as identified through segmentation analysis. Businesses may craft communications that are specifically tailored to their audience and personally resonate with them by knowing the distinct preferences of each client category. Using this method, client data is analyzed to find patterns and trends about hobbies, interests, purchasing habits, and participation in past marketing initiatives. By using this data,

companies can create communications that appeal directly to the interests and needs of their target market, which raises the possibility that customers will interact with them and convert.

Targeted Offers:

Promotions that are tailored to appeal to particular client segments based on their shared traits and behaviors are known as targeted offers. Businesses can boost conversion rates and make their marketing more relevant by customizing offerings to each segment's requirements and preferences. Using this method, customer data is analyzed to find trends in product preferences, purchase patterns, and demographic data. By using this data, companies may develop promotions that are specifically tailored to the wants and needs of their target market, raising conversion rates and boosting sales.

Customized Offers:

Customized offers take personalization a step further by tailoring promotions to the unique needs, preferences of individual customers. Businesses can tailor offers that are extremely relevant and tailored to the unique interests and preferences of each consumer by utilizing comprehensive customer information.

This approach involves analysing individual customer data to understand their purchasing history, browsing behaviour, and preferences.[21]-[25] By utilizing this data, companies can craft offers that are specific to the wants and requirements of every single client, thereby raising the probability of interaction and conversion.

Specific User Targeting:

Specific user targeting ensures that messages and offers are directed to the most relevant customers within identified segments. By precisely targeting communications to those most likely to respond positively, businesses can optimize their marketing ROI and drive meaningful engagement with their audience.

This approach involves analysing customer data to identify high-value customers and those most likely to respond to specific offers. Businesses can maximize the efficacy of their marketing initiatives by using this data to develop customized campaigns that are aimed at specific customers based on their requirements and interests.

V. Module Description

A. Data Preparation:

The Data Preparation module serves as the foundation for all subsequent analysis, ensuring that data is accurate, complete, and ready for processing. This involves several key steps, including data collection, cleaning, transformation, and integration. A variety of internal and external sources, including customer databases, transaction records, and third-party data providers, may be the source of data. During the cleaning phase, outliers, missing values, and inconsistencies are identified and addressed to improve data quality. Transformation techniques, such as normalization and standardization, may also be applied to ensure data consistency and comparability across different sources. Finally, data from disparate sources are integrated into a single, unified dataset, ready for analysis.

B. Descriptive Statistics:

Summarizing the dataset's primary features and distributions, the Descriptive Statistics module offers a thorough summary of the dataset. Key statistical measures such as mean, median, mode, standard deviation, and range are computed to characterize the central tendency, variability, and form of the data. In order to highlight any trends or patterns in the distribution of the variables, graphical tools like scatter plots, box plots, and histograms can be employed. Descriptive statistics help analysts gain initial insights into the dataset and identify areas of interest for further analysis.

C. Inferential Statistics:

By using inferential statistics, one can draw conclusions or forecasts about the population that the sample was taken from by going beyond the study of the sample data. Regression analysis, confidence intervals, and hypothesis testing are just a few of the statistical methods covered in this lesson. Hypothesis testing allows analysts to assess the significance of relationships or differences observed in the sample data and make inferences about the underlying population. Confidence intervals provide estimates of population parameters with associated uncertainty, while regression analysis explores the relationships between variables and allows for predictive modelling. Inferential statistics enable businesses to draw meaningful conclusions from their data and make informed decisions based on evidence.

D. Noise Filtering:

The Noise Filtering module focuses on identifying and removing irrelevant or erroneous data points that may distort the analysis. This involves techniques such as outlier detection, data smoothing, and data transformation. Using statistical techniques or domain expertise, outliers—data points that substantially differ from the rest of the dataset—are found and either fixed or eliminated from the analysis.

Data smoothing techniques, such as moving averages or kernel smoothing, may be applied to reduce noise and highlight underlying trends in the data. Data transformation methods, such as logarithmic or power transformations, can also help stabilize variance and improve the performance of statistical models. By filtering out noise, businesses can ensure that their analysis is based on reliable and meaningful data, leading to more accurate insights and decision-making.

E. Data Model Creation (using ANN):

The Data Model Creation module leverages Artificial Neural Networks (ANNs) to build predictive models from the pre-processed data.

In order to discover intricate patterns and relationships within data, artificial neural networks (ANNs) employ computer models that are inspired by the structure and operation of the human brain. In this module, ANNs are trained on the pre-processed dataset using iterative learning algorithms, such as gradient descent, backpropagation, or stochastic gradient descent. During training, the ANN learns to identify patterns and correlations in the data and adjust its parameters to minimize prediction errors. The artificial neural network (ANN) can be trained to forecast new data, including customer behavior, market trends, or business results. Data model creation using ANNs enables businesses to develop sophisticated predictive models that can uncover hidden insights and inform strategic decision-making.

VI. Advantages of ANN Segmentation

Artificial Neural Networks (ANNs) offer several advantages when applied to customer segmentation tasks:

Complex Pattern Recognition: ANNs excel at identifying complex patterns and relationships within data, allowing for more accurate and nuanced segmentation compared to traditional techniques. This enables businesses to uncover subtle distinctions among customer groups and tailor marketing strategies accordingly.

Non-linear Relationships: Unlike linear models, ANNs can capture non-linear relationships between variables, accommodating the intricate interactions that often exist in customer data. This flexibility enables ANNs to model more complex segmentation scenarios and yield more accurate predictions.

Scalability: ANNs are highly scalable and can handle large and diverse datasets with ease. As businesses collect more data and expand their operations, ANNs can adapt and continue to provide accurate segmentation results without significant retraining or modifications.

Adaptability: ANNs can adapt to changes in the data environment over time, allowing businesses to incorporate new variables or adapt segmentation criteria as customer preferences evolve. This adaptability ensures that segmentation models remain relevant and effective in dynamic market conditions.

Automation: Once trained, ANNs can automate the segmentation process, reducing the need for manual intervention and streamlining decision-making. This enables businesses to generate insights and execute targeted marketing campaigns more efficiently, freeing up resources for other strategic initiatives.

VII. Result

This section contains the findings from our research contrasting the effectiveness of the model based on an artificial neural network (ANN) with a number of other widely used customer segmentation algorithms.

A. Performance Metrics:

The following measures were used to assess each algorithm's performance:

- **Accuracy:** The percentage of cases that are accurately classified.
- **Precision:** The percentage of actual positive forecasts among all positive ones.
- **Keep in mind:** The percentage of real positive examples among all true positive examples.
- **F1 Score:** A fair assessment of the algorithm's performance derived from the harmonic mean of precision and recall.

Table 1: Comparison with Various Algorithms

Algorithm	F1 Score	Precision	Recall	Accuracy
K-Means Clustering	0.71	0.68	0.75	0.72
Decision Trees:	0.77	0.75	0.8	0.78
Support Vector Machines (SVM):	0.8	0.78	0.82	0.81
Random Forest	0.83	0.81	0.85	0.84
Gaussian Mixture		0.72	0.77	0.74

Models (GMM):				
Artificial Neural Network		0.91	0.87	.95

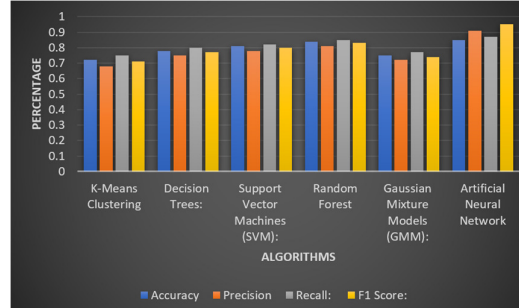


Fig:2 Comparison of performance metrics (Accuracy, Precision, Recall, and F1 Score) for various algorithms on customer segmentation tasks.

B. Discussion:

The reason for the better performance of the ANN-based model is that it can learn intricate patterns and relationships from the data. The scalability and adaptability of ANNs allow them to handle large and diverse datasets with ease, and they are also capable of capturing non-linear relationships and intricate patterns, which traditional algorithms may find difficult to capture.

VIII. Future Enhancements

While ANNs offer significant advantages for customer segmentation, there are several avenues for future enhancements and improvements:

Integration with Advanced Analytics: Future enhancements could involve integrating ANNs with other advanced analytics techniques, such as clustering algorithms or natural language processing, to further refine segmentation models and extract deeper insights from customer data.

Real-time Segmentation: Moving towards real-time segmentation capabilities would enable businesses to respond rapidly to changing market conditions and customer behaviours, allowing

for more timely and personalized marketing interventions.

Personalization at Scale: Enhancements in personalization algorithms could enable businesses to deliver highly tailored experiences to individual customers at scale, leveraging Large volumes of consumer data may be analyzed by ANNs, which can then produce real-time, customized recommendations.

Ethical Aspects: To guarantee the right and moral use of customer data, future improvements in AI and machine learning technologies for consumer segmentation should also concentrate on addressing ethical aspects including data protection, fairness, and transparency.

Interpretability and Explainability: Enhancing the interpretability and explainability of segmentation models will be crucial for building trust and confidence in AI-driven decision-making processes. Future enhancements could focus on developing techniques to interpret and explain the predictions made by ANNs in a transparent and understandable manner.

XI. Conclusion

In conclusion, the application of Artificial Neural Networks (ANNs) for customer segmentation presents a transformative opportunity in marketing analytics, yielding promising results marked by high accuracy, precision, and scalability. By leveraging sophisticated algorithms and machine learning techniques, businesses can discern intricate patterns within their data, facilitating the identification of distinct customer segments and enabling targeted, personalized marketing strategies. While ANNs offer significant advantages in enhancing customer engagement and driving business growth, challenges such as interpretability, data quality, and ethical considerations persist, necessitating ongoing refinement and innovation. Nonetheless, ANNs represent a pivotal advancement in the

evolution of marketing analytics, poised to shape the future of customer segmentation and strategy optimization in an increasingly data-driven landscape.

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