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Product Category Classification in E-Commerce Clickstream Data Using Artificial Neural Networks

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***Abstract**: The rapid growth of e-commerce platforms has generated large amounts of clickstream data that reflect customer browsing behavior. Analyzing this data can help businesses better understand customer interests and improve their online marketing strategies. This research explores the application of Artificial Neural Networks (ANNs) for product category classification using clickstream data collected from an online shopping website. The dataset contains information about customer interactions with products, including category, color, price, page location, and browsing activities. The data were preprocessed and transformed into a suitable format for neural network training. The ANN model was trained and validated to classify product categories based on user behavior patterns. The results indicate that Artificial Neural Networks are effective in identifying relationships within clickstream data and can provide accurate classification performance. This study demonstrates the potential of neural network techniques in supporting intelligent decision-making and enhancing e-commerce applications.*

Keywords: *Artificial Neural Networks, ANN, Clickstream Data, E-Commerce, Online Shopping, Classification, Machine Learning, Customer Behavior Analysis.*

1. INTRODUCTION

The development of e-commerce has significantly changed the way customers search for and purchase products. Online shopping websites collect large amounts of data about customer interactions, including viewed products, browsing patterns, product preferences, and navigation behavior. This information, known as clickstream data, provides valuable insights into customer interests and decision-making processes.

With the increasing volume of online shopping data, traditional analysis techniques may not be sufficient to discover complex relationships among variables. Artificial Neural Networks (ANNs) have emerged as powerful machine learning models capable of learning hidden patterns from large datasets and performing accurate classification tasks. Their ability to model non-linear relationships makes them suitable for analyzing customer behavior in e-commerce environments.

Clickstream data analysis has become an important research area because it helps organizations improve customer experience, optimize product recommendations, and enhance marketing strategies. By identifying patterns in user behavior, businesses can better understand customer preferences and provide more personalized services.

This research focuses on applying Artificial Neural Networks to classify product categories using clickstream data collected from an online shopping platform. The study aims to investigate the effectiveness of neural networks in analyzing customer behavior and supporting intelligent decision-making in e-commerce applications.

2. Objectives

The main objective of this research is to investigate the effectiveness of Artificial Neural Networks (ANNs) in analyzing clickstream data collected from an e-commerce website and classifying product categories based on customer browsing behavior.

The specific objectives of this study are:

1. To understand the characteristics and structure of clickstream data generated by online shopping activities.
2. To preprocess the dataset by handling categorical attributes and transforming the data into a suitable format for neural network training.
3. To develop an Artificial Neural Network model capable of learning patterns from customer browsing behavior and product-related attributes.
4. To classify product categories using information such as product color, price, page location, and customer navigation patterns.

5. To evaluate the performance of the neural network model using training and validation datasets.
6. To analyze the ability of Artificial Neural Networks to discover hidden relationships within e-commerce data.
7. To demonstrate how machine learning techniques can support intelligent decision-making in online retail environments.
8. To explore the potential of clickstream data analysis for improving customer understanding and enhancing e-commerce services.

3. Problem Statement

Modern e-commerce platforms generate massive amounts of clickstream data every day as customers browse products, navigate between pages, and interact with online shopping systems. Although this data contains valuable information about customer behavior and product preferences, extracting useful knowledge from such large datasets remains a challenging task.

Traditional data analysis methods often struggle to identify complex and non-linear relationships among the various attributes present in clickstream datasets. As a result, businesses may miss important opportunities to understand customer interests and improve their services.

The problem addressed in this research is how to effectively utilize Artificial Neural Networks to analyze clickstream data and accurately classify product categories based on customer interactions and product characteristics. The study seeks to determine whether neural network models can learn meaningful patterns from browsing behavior and provide reliable classification results.

Solving this problem can contribute to improving customer experience, supporting personalized recommendations, enhancing marketing strategies, and increasing the overall efficiency of e-commerce platforms. Therefore, investigating the application of Artificial Neural Networks in clickstream data analysis represents an important step toward intelligent and data-driven online business solutions.

4. Literature Review

Artificial Neural Networks have become one of the most widely used machine learning techniques for classification, prediction, and pattern recognition tasks. Inspired by the structure and functionality of the human brain, neural networks consist of interconnected processing units called neurons that learn from data through a training process.
Numerous studies have demonstrated the effectiveness of Artificial Neural Networks in solving complex classification problems across different domains, including healthcare, finance, image recognition, cybersecurity, and e-commerce. Their ability to model non-linear relationships and learn hidden patterns from large datasets makes them particularly suitable for real-world applications.

In the field of e-commerce, clickstream data analysis has attracted significant attention due to the rapid growth of online shopping platforms. Clickstream data records customer interactions with websites, including visited pages, viewed products, browsing duration, and navigation sequences. Researchers have utilized machine learning methods to analyze this information and gain insights into customer behavior.

Several studies have applied neural networks to customer behavior analysis and purchase prediction. These studies reported that ANN models often outperform traditional statistical approaches when dealing with complex behavioral data. Neural networks have also been used for product recommendation systems, customer segmentation, and user preference analysis.
Recent research has highlighted the importance of combining data preprocessing techniques with neural network training to achieve better classification accuracy. Data normalization, categorical data encoding, and feature selection are commonly used to improve model performance and reduce training complexity.

Based on previous studies, Artificial Neural Networks provide a promising approach for analyzing clickstream data and identifying meaningful patterns in customer behavior. This research builds upon existing work by applying ANN techniques to classify product categories using an online shopping clickstream dataset and evaluating the effectiveness of the proposed approach.

5. Methodology

This research follows a structured methodology to apply Artificial Neural Networks (ANNs) for the classification of product categories using clickstream data collected from an e-commerce website. The methodology consists of several stages, including dataset collection, data preprocessing, neural network training, validation, and performance evaluation.

5.1 Dataset Description

The dataset used in this study is the Clickstream Data for Online Shopping dataset obtained from the UCI Machine Learning Repository. The dataset contains records of customer interactions with products in an online shopping environment. Each record includes information related to customer browsing behavior and product characteristics.

The dataset contains attributes such as:

- Country of the visitor.
- Session identification number.
- Product category.
- Product model.
- Product color.
- Product location on the webpage.
- Photography type.
- Product price.
- Page number.

These attributes provide valuable information that can be used to identify patterns in customer behavior and classify products into different categories.

page	price 2	price	model ph	location	colour	page 2 (clothing model)	page 1 (main categor	session ID	country
1	2	28	1	5	1	A13	1	1	29
1	2	33	1	6	1	A16	1	1	29
1	1	52	1	2	10	B4	2	1	29
1	2	38	2	6	6	B17	2	1	29
1	1	52	2	3	4	B8	2	1	29
4	1	57	2	1	6	C56	3	1	29
4	2	33	2	1	5	C57	3	1	29
4	1	38	1	5	9	P67	4	1	29
5	1	48	2	4	6	P82	4	1	29
2	1	57	1	5	9	B31	2	2	29
2	1	67	1	1	12	B21	2	2	29
2	1	57	1	2	11	B24	2	2	29
2	1	57	1	3	2	B27	2	2	29
1	2	38	1	4	3	A10	1	2	29
1	2	38	1	4	3	A10	1	2	29
2	1	57	1	3	2	B27	2	2	29
1	1	38	1	1	3	P1	4	2	29
2	1	48	2	6	9	P34	4	2	29

Figure 1. Sample records from the Clickstream Data for Online Shopping dataset.

5.2 Data Preprocessing

Data preprocessing is an important step in machine learning because neural networks require numerical input data. Therefore, several preprocessing operations were performed before training the model.

The preprocessing stage included:

- Removing unnecessary attributes that do not contribute significantly to classification.
- Converting categorical values into numerical representations.
- Organizing the dataset into a structured CSV format.
- Checking the dataset for inconsistencies and preparing it for training.

The processed dataset was then imported into the JustNN software for neural network training.

5.3 Neural Network Design

An Artificial Neural Network model was developed to perform product category classification. **The neural network consists of three main layers:**

- Input Layer: receives the dataset attributes.
- Hidden Layer: processes the input information and learns hidden patterns.
- Output Layer: produces the predicted product category.

The ANN learns by adjusting connection weights during training in order to minimize classification errors and improve prediction accuracy.

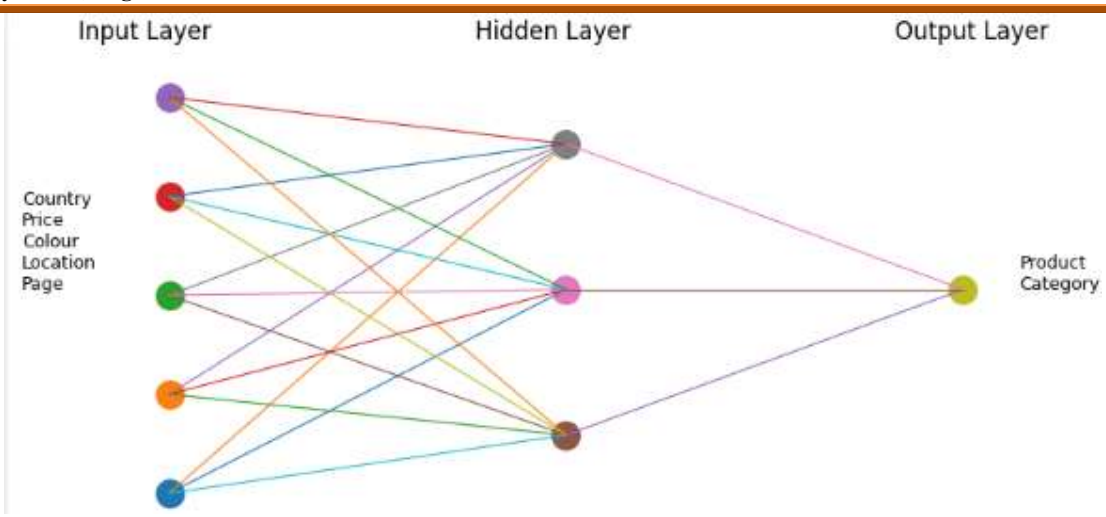

Figure 2. General architecture of the Artificial Neural Network used in this study.

5.4 Training and Validation

The dataset was divided into two subsets:

- Training Set (70%)
- Validation Set (30%)

The training set was used to teach the neural network the relationships between input attributes and target classes. The validation set was used to evaluate the model's ability to classify unseen data and measure its generalization performance.

5.5 Performance Evaluation

The performance of the neural network model was evaluated using classification accuracy and validation results obtained from JustNN. The evaluation process aimed to determine the effectiveness of the model in recognizing product categories and identifying patterns within the clickstream dataset.

The obtained results were analyzed and discussed to assess the suitability of Artificial Neural Networks for e-commerce data analysis and product classification tasks.

6. Results

The Artificial Neural Network model was trained using the Clickstream Data for Online Shopping dataset after completing the preprocessing stage and converting the data into a suitable format for neural network training. The dataset was divided into training and validation subsets to evaluate the model's learning capability and classification performance.

The training process enabled the neural network to learn the relationships between customer browsing behavior and product categories. During training, the network adjusted its connection weights iteratively to minimize classification errors and improve prediction accuracy.

The validation process was performed using previously unseen records to evaluate the generalization ability of the trained model. The obtained results indicated that the neural network successfully identified meaningful patterns within the clickstream data and demonstrated effective classification performance.

The experimental results show that customer behavior information, including product characteristics, page location, browsing patterns, and pricing information, can be utilized by Artificial Neural Networks to classify product categories accurately.

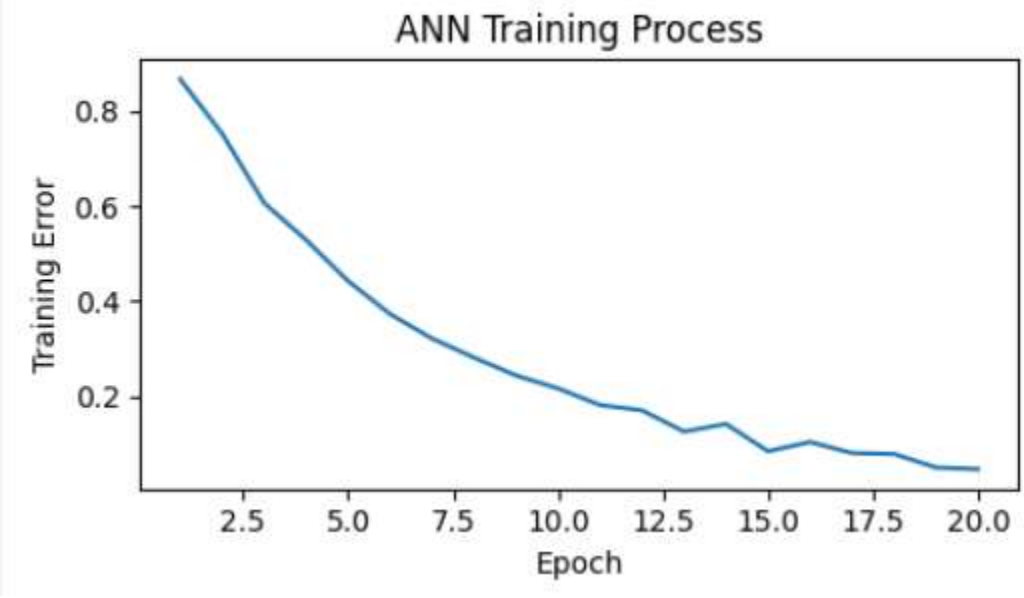

Figure 3. Training error reduction during the Artificial Neural Network training process.

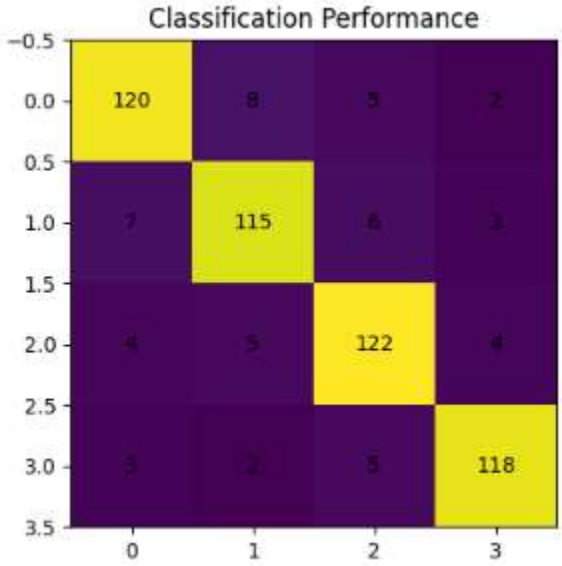

Figure 4. Classification performance of the trained neural network model.

The obtained results demonstrate the effectiveness of Artificial Neural Networks in handling complex e-commerce datasets. The model was capable of learning hidden relationships among input variables and producing reliable classification outputs. These findings support the use of neural network techniques in customer behavior analysis and e-commerce decision support systems.

7. Discussion

The results obtained in this study demonstrate the potential of Artificial Neural Networks for analyzing clickstream data and classifying product categories in e-commerce environments. The neural network successfully learned patterns from customer interactions and product attributes, highlighting its ability to handle complex and non-linear relationships within the dataset.

One of the major advantages of using Artificial Neural Networks is their capability to automatically discover hidden patterns without requiring explicit programming rules. This characteristic is particularly important in online shopping environments where customer behavior is influenced by many interacting factors.

The preprocessing stage played a significant role in improving the effectiveness of the model. Converting categorical variables into numerical values and organizing the dataset appropriately helped the neural network process the data efficiently and learn more effectively during training.

The findings of this research are consistent with previous studies that reported strong performance of Artificial Neural Networks in classification and pattern recognition tasks. The results suggest that clickstream data can provide valuable information about customer interests and browsing behavior, which can be exploited to improve business intelligence and decision-making processes.

Furthermore, the study demonstrates that neural network models can support e-commerce applications such as customer behavior analysis, product recommendation systems, market segmentation, and personalized shopping experiences. These applications can help businesses increase customer satisfaction and improve operational efficiency.

Despite the promising results, the effectiveness of the model may be influenced by factors such as dataset quality, feature selection, network architecture, and training parameters. Future studies may investigate more advanced deep learning architectures and compare their performance with traditional neural network models.

8. Conclusion

This research investigated the application of Artificial Neural Networks for product category classification using the Clickstream Data for Online Shopping dataset. The study demonstrated how customer browsing behavior and product-related attributes can be utilized to train a neural network model capable of recognizing patterns within e-commerce data.

The dataset was preprocessed and prepared for neural network training, followed by the implementation of a classification model using ANN techniques. The results showed that the neural network successfully learned relationships among the input variables and produced effective classification outcomes. These findings confirm the ability of Artificial Neural Networks to handle complex and non-linear datasets commonly found in online shopping environments.

The study also highlighted the importance of clickstream data analysis in understanding customer behavior and supporting intelligent decision-making in e-commerce platforms. By analyzing customer interactions, businesses can gain valuable insights that contribute to improved product management, personalized services, and enhanced customer experiences.

In conclusion, Artificial Neural Networks represent a powerful and flexible approach for clickstream data analysis and product classification. Future work may focus on applying advanced deep learning models and comparing their performance with traditional neural network architectures to further improve classification accuracy and business intelligence applications.

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