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Image classification with neural networks improves consumer behavior in college students

Clasificación de imágenes con redes neuronales mejora el comportamiento del consumidor en estudiantes universitarios

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Abstract

The study aimed to determine how image classification using neural networks (NN) improves consumer behavior among university students. An applied research study was proposed, with a pre-experimental design and explanatory level. Data was collected and processed using non-participatory techniques, analyzing the digital interaction of university students. The data was cleaned and organized for analysis, in which machine learning techniques were applied. The use of TensorFlow and TensorFlow Datasets simplified the preprocessing and training of the model, ensuring efficient flow and optimized performance through image normalization and data batch configuration. The model used detailed visualizations with clear indicators to analyze its performance, highlighting successes and errors, which facilitated its interpretation and adjustment. The pre-trained VGG16 model, adjusted in 15 epochs, achieved a validation accuracy of 97.4%, demonstrating its high effectiveness on unseen data. The results highlight the transformative impact of CNNs on product classification, improving the user experience and optimizing consumer satisfaction and perception on digital fashion platforms. The implementation of the RN-based image classifier significantly improved the user experience, shifting from a negative perception to 90% positive ratings. The Wilcoxon test confirmed that this change reflects a real improvement in the behavior and decisions of college students as consumers.

Keywords: neural networks, image classifier, machine learning

Resumen

El estudio tuvo el objetivo de determinar de qué manera el clasificador de imágenes con redes neuronales (RN) mejora el comportamiento del consumidor en estudiantes universitarios. Se planteó una investigación de tipo aplicado, con un diseño preexperimental y nivel explicativo. Se recolectaron y procesaron datos mediante técnicas no participativas, analizando la interacción digital de estudiantes universitarios. Los datos fueron limpiados y organizados para su análisis, en el que se aplicaron técnicas de Machine Learning. El uso de TensorFlow y TensorFlow Datasets simplificó el preprocesamiento y entrenamiento del modelo, asegurando un flujo eficiente y

un desempeño optimizado mediante la normalización de imágenes y la configuración de lotes de datos. El modelo empleó visualizaciones detalladas con indicadores claros para analizar su rendimiento, destacando aciertos y errores, lo que facilitó su interpretación y ajuste. El modelo preentrenado VGG16, ajustado en 15 épocas, alcanzó una precisión de validación del 97.4 %, evidenciando su alta eficacia en datos no vistos. Los resultados destacan el impacto transformador de las CNNs en la clasificación de productos, mejorando la experiencia del usuario y optimizando la satisfacción y percepción del consumidor en plataformas de moda digitales. La implementación del clasificador de imágenes basado en RN mejoró significativamente la experiencia del usuario, pasando de una percepción negativa a un 90% de evaluaciones positivas. La prueba de Wilcoxon confirmó que este cambio refleja una mejora real en el comportamiento y las decisiones de los estudiantes universitarios como consumidores.

Palabras clave: redes neuronales, clasificador de imágenes, machine learning

Introduction

Currently, the rapid pace of technological advancements and increasing digitalization have radically transformed various spheres of everyday life, with artificial intelligence (AI) and deep learning emerging as transformative forces across numerous sectors (Akbiyik, 2019). Image classification using neural networks, in particular, has established itself as a central component of this technological revolution. From applications in critical areas such as medicine to integration in advanced advertising strategies, these technologies are reshaping how we interact with the visual world (Artola, 2019).

In Europe, the use of neural networks has been extensively researched and adopted, particularly highlighting their capacity to enhance precision in market segmentation and the personalization of marketing campaigns (Bennett & Lemoine, 2019). In America, this trend has intensified, with studies demonstrating how these advancements can influence purchasing decisions, especially among younger demographic groups (Davenport & Ronanki, 2018). In this context, Peru, and specifically Lima, presents a unique landscape where the adoption of emerging technologies is less explored, especially within the university sector.

This research aims to examine how image classification based on neural networks can model, impact, and predict consumption preferences among university students. It seeks to provide valuable insights that contribute to the understanding of digital marketing strategies, particularly those utilizing personalized visual content.

In Latin America, differences in consumer trust perception are evident, with Brazil being a notable case where trust in online purchases is remarkably high, in contrast to Peru, where significant challenges persist in motivating purchases on digital platforms (Hurwitz & Kirsch, 2018). This phenomenon highlights the disconnect many consumers experience, avoiding products that may not resonate with their expectations or previous experiences.

Therefore, the following general problem is posed: How does the image classifier using neural networks enhance consumer behavior on digital platforms among university students? The specific problems are: 1) How does the image classifier using neural networks enhance the motivation of consumer behavior among university students? 2) How does the image classifier using neural networks enhance the perception of consumer behavior among university students? 3) How does the image classifier using neural networks enhance the learning of consumer behavior among university students? and 4) How does the image classifier using neural networks enhance the attitude of consumer behavior among university students?

Additionally, the general objective is stated as follows: To determine how the image classifier using neural networks improves consumer behavior among university students. The specific objectives are: 1) To determine how the image classifier using neural networks enhances the motivation of consumer behavior among university students. 2) To determine how the image classifier using neural networks enhances the perception of consumer behavior among university students. 3) To determine how the image classifier using neural networks improves the learning of consumer behavior among university students. and 4) To determine how the image classifier using neural networks enhances the attitude of consumer behavior on digital platforms among university students.

Finally, the general hypothesis is proposed: The image classifier based on neural networks improves consumer behavior among university students. The specific hypotheses are: 1) The image classifier based on neural networks enhances the motivation of consumer behavior among university students. 2) The image classifier based on neural networks improves the perception of consumer behavior among university students. 3) The image classifier based on neural networks enhances the learning of consumer behavior among university students. and 4) The image classifier based on neural networks improves the attitude of consumer behavior among university students.

Research on image classification using neural networks and its impact on consumer behavior among university students is highly relevant, as this group represents a significant portion of the market that rapidly adopts new technologies. By understanding how these tools influence their purchasing decisions, businesses can tailor their digital marketing strategies to enhance consumer experience and increase conversion rates. Furthermore, the findings of this study will provide educational institutions with valuable insights on how to integrate emerging technologies into their curricula, preparing students for a constantly evolving job market.

On another note, Kumar et al. (2022), in their study on image classification, emphasize the importance of Convolutional Neural Networks (CNNs) and efficient processing systems for generating thematic maps, highlighting the need for careful selection of data features and the employment of classification techniques such as decision trees and knowledge-based methods, which are essential for integrating information from multiple sources. They also underscore the potential of integrating GIS, remote sensing, and expert systems, an emerging field that requires further research to refine classification processes. The article also discusses how deep learning and computer vision, through CNNs, can enhance classification accuracy by combining features from different layers of these networks. To demonstrate this, they developed a model using the CIFAR10 dataset, utilizing Keras as an API and stochastic gradient descent for optimization.

Ferreira (2021), in their study, examines how consumers interact with these technologies in the marketing domain. The study analyzes their impact on customer experience throughout the purchasing process, from information search to post-sale support, in both digital and physical environments. Focusing on voice-controlled personal assistants, Ferreira explores how these devices evoke emotions similar to interpersonal relationships, such as passion and commitment, fostering valuable behaviors for businesses. The research is structured in two parts: the first analyzes how consumer love-related emotions influence loyalty towards these technologies, drawing on theories such as the S-O-R model and the Triangular Theory of Love. The second examines how different dimensions of consumer experience impact attachment to voice assistants and how this attachment affects transactional responses, such as purchases, and non-transactional responses, such as recommendations. This analysis employs theoretical frameworks like the S-O-R model, Attachment Theory, and brand engagement. The work provides a comprehensive view of the emotional and behavioral dynamics between consumers and intelligent technologies, offering valuable insights for improving marketing strategies and strengthening the relationship between brands and users.

Briones (2020), in their research, analyzes the importance of consumer experience as a key element for standing out in a competitive market. Focused on the Cajamarca shopping center in 2019, the study aimed to examine the relationship between customer experience and satisfaction levels. A correlational and descriptive research design was employed, applying surveys to a sample of 385 customers. The collected data were analyzed using statistical tools such as Excel and SPSS 25, and their reliability was verified using Cronbach's alpha. The results showed a significant and direct relationship between customer experience and satisfaction, evidenced by a Pearson coefficient of 0.386. This finding indicates that improving the experience offered by the shopping center also increases customer satisfaction. While it is concluded that the shopping center provides an excellent experience that keeps its customers satisfied, the study notes that there are still aspects that do not fully meet the expectations of the target audience, representing an opportunity to continue enhancing its value proposition.

Artola (2019) analyzes the impact of Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) on technology and everyday life. AI, as a branch of computing that emulates human activities, has led to the development of ML, which focuses on automatic learning, and DL, which replicates data processing similar to the human brain through neural networks. These technologies have diverse applications, such as facial recognition and the generation of medical assessments. The study focuses on convolutional neural networks, which are essential for image analysis and categorization, and discusses how to train them to maximize accuracy, sensitivity, and specificity. Additionally, it addresses the most commonly used programming languages in AI, databases for processing, and the performance of these networks, highlighting both their theoretical foundations and practical applications in real-world problems.

Overall, these studies emphasize the influence of user experience and emotions on satisfaction and behavior, while underscoring the role of AI and deep learning in optimizing key processes. This highlights the importance of innovative approaches for more effective marketing strategies and analysis.

Independent variable

X: Image classification with neural networks.

Artificial neural networks (ANNs) are essential in the development of artificial intelligence, particularly in image classification. These networks are effective at identifying patterns in visual data, improving classification accuracy by learning from large datasets (Goodfellow et al., 2016). The use of deep neural networks, particularly

convolutional neural networks (CNNs), has proven relevant, as they enable the labeling of images based on specific features (Li et al., 2023).

Since 2020, innovations in CNNs have addressed limitations such as the "curse of dimensionality," achieving efficient convergence in classification (Kohler et al., 2020). Furthermore, the implementation of Long Short-Term Memory (LSTM) networks has enhanced the classifiers' ability to associate previous experiences and adapt to new data (Yang & Ding, 2020). Advances such as rotational symmetric models and Siamese neural networks (SNNs) have allowed classifiers to specialize in identifying complex patterns, thereby increasing accuracy in specific tasks, as corroborated by Kohler and Walter (2022), in agreement with Naihua et al. (2024).

These advancements in image classification through ANNs and new optimization methodologies present significant potential for improving the understanding of consumer behavior. By more accurately classifying the preferences and behaviors of university students, it is possible to directly impact marketing strategies and product development aimed at this group (Hernández & Konig, 2019).

Dimensions

X1: Network architecture.

The choice of the type of neural network, especially convolutional neural networks (CNNs), is fundamental for image classification. CNNs can extract hierarchical features from images by using convolutional and pooling layers, allowing them to effectively identify complex visual patterns (Goodfellow, Bengio, & Courville, 2016).

X2: Dataset Characteristics.

This dimension encompasses both the size and diversity of the dataset used to train the model. A large and varied dataset is crucial for improving model generalization and avoiding overfitting. Additionally, it is important to consider the quality of the images and the representation of classes within the dataset (Li, Wu, & Zhang, 2023).

X3: Evaluation Metrics.

The metrics used to evaluate the model's performance are essential for determining its effectiveness. Key metrics include accuracy, recall, and F1-score, which are critical tools for measuring the model's ability to classify images into their respective categories (Schwarz & Lee, 2023).

Dependent Variable

Y: University Student Consumer Behavior.

Consumer experience refers to the overall perception a customer has of a brand or product after interacting with it. In the university context, this experience encompasses all aspects of students' interactions with services, products, and resources offered by the educational institution. The quality of this experience can significantly influence students' satisfaction, loyalty, and future behavior (Rangel et al., 2021).

Factors influencing university student consumer experience

The university student consumer experience is influenced by various fundamental factors:

Service quality. First and foremost, service quality plays a critical role. The efficiency and effectiveness of administrative, academic, and technical support services are essential to ensuring student satisfaction (Bustamante et al., 2022).

Learning environment. Additionally, the learning environment significantly impacts the student experience. An environment with adequate infrastructure, quality educational resources, and an inclusive climate contributes meaningfully to student satisfaction and development (Contreras et al., 2019).

Technology and access to information. Finally, technology and access to information are determining factors. The availability and ease of access to advanced technologies and digital resources enrich the educational experience, facilitating both learning and research (Romero et al., 2016).

Dimensions

Y1: Motivation of consumer behavior in university students.

Motivation plays a fundamental role in consumer behavior, and in the case of university students, it is influenced by a variety of needs and desires. Among these are the pursuit of academic recognition, the desire to acquire knowledge, and the improvement of both personal and professional skills. From the perspective of Maslow's Theory, the hierarchy of human needs can be applied to the university context, where basic needs, such as physiological and safety needs, must first be satisfied before students seek to fulfill higher needs, such as recognition and self-actualization. Furthermore, Self-Determination Theory emphasizes that students are motivated by their need for competence, autonomy, and social relationships—factors that significantly influence their drive to achieve their academic and personal goals (Deci & Ryan, 2000). On the other hand, indicators such as purchase motivation, exploration of new products, coinciding interests, system reuse, immediate purchase interest, motivation of consumer behavior in university students, and perception of consumer behavior in university students are noteworthy. Perception is the process through which individuals select, organize, and interpret information to construct a coherent view of their environment. In the case of university students, the way they

perceive educational quality, campus infrastructure conditions, and support services directly affects their consumption decisions and behaviors. According to Kotler and Keller (2016), consumer perception is subjective and can be shaped by both internal factors, such as previous experiences and expectations, and external factors, such as marketing strategies and the opinions of other students.

Y3: Learning consumer behavior in university students.

Learning involves a change in consumer behavior due to experience and the information acquired. In the university context, students learn not only through formal classroom instruction but also through social interactions and practical experiences. Bandura's social learning theory posits that students acquire knowledge by observing and imitating the behavior of their peers and role models. Additionally, the development of critical skills is promoted through participation in collaborative activities and practical projects (Bruner, 1966). Furthermore, indicators such as learning about new products, category discovery, product education, facilitation of learning, enhancement of general knowledge, and the attitude of consumer behavior in university students are relevant.

Attitude is defined as an individual's learned disposition to respond positively or negatively to an object, person, or situation. In the case of university students, their attitudes toward education, professors, and the institution significantly influence their behavior as consumers. The Theory of Reasoned Action, proposed by Fishbein and Ajzen, asserts that attitudes, along with subjective norms, affect behavioral intentions, which in turn determine actual actions. In the university setting, a positive attitude toward education can foster greater engagement and academic success, along with indicators such as overall attitude, recommendations to others, trust in the system, and future usage

Methodology

The study is applied and explanatory in nature, aimed at solving problems and predicting outcomes. It seeks to measure perceptions regarding image classification using neural networks and its relationship with consumer behavior among university students. It is classified as explanatory because it analyzes and explains causal relationships between variables, investigating how an image classifier using Artificial Neural Networks (ANN) influences educational experience. The pre-experimental design evaluates the effects of this system on learning, exploring its impact on user satisfaction and interaction, which aligns with explanatory studies.

Regarding the population, it refers to students from UNFV using digital platforms, comprising 500 students in Metropolitan Lima. For the image classification model, 625 training images and 205 test images were included. Additionally, a group of 50 university students from UNFV was selected for pretests and posttests in a pre-experimental design, following specific research criteria. The research utilized Deep Learning techniques, specifically the VGG16 model, and surveys to study consumer experience among university students. The VGG16 model was chosen for its proven effectiveness in image classification. A questionnaire designed according to Denscombe's guidelines was also applied to collect quantitative data on satisfaction and usability of the proposed system.

Results and discussion

Figure 1

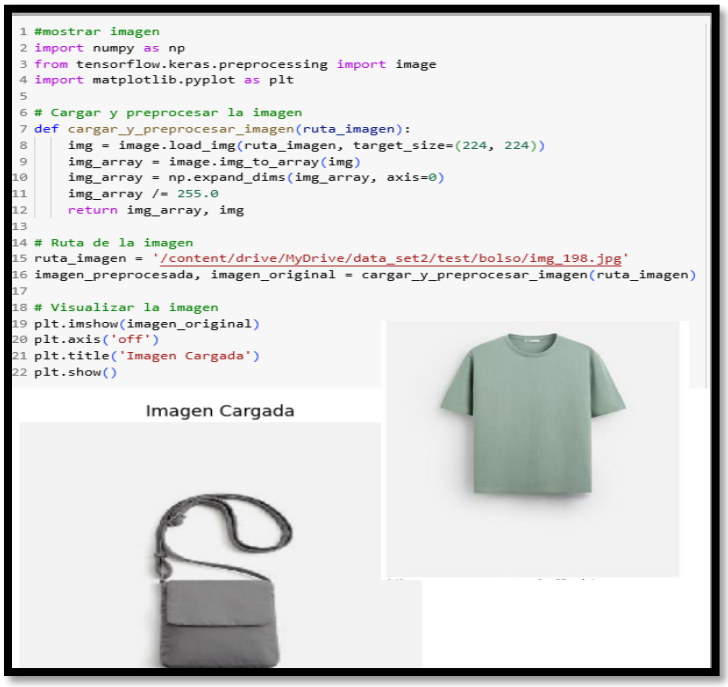
Loading of the pre-trained VGG16 model with fine-tuning layers for image classification

```python
#Cargar el modelo
import tensorflow as tf
from tensorflow.keras.applications import VGG16
from tensorflow.keras import layers, models
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from google.colab import drive
drive.mount('/content/drive')

# Definir la arquitectura del modelo
vgg16 = VGG16(weights='imagenet', include_top=False, input_shape=(224, 224, 3))

# Congelar las primeras capas
for layer in vgg16.layers[:15]:
    layer.trainable = False
```

The image shows the training process of the VGG16 model over 15 epochs, detailing the loss and accuracy metrics during the training phase.

Figure 2

Training of the VGG16 model in TensorFlow



In Figure 2, the image presents the code for loading and testing the VGG16 model in TensorFlow. Its architecture is defined, freezing the initial layers and adding new classification layers for a specific dataset. The model construction is also verified, and the trained weights are loaded, ensuring proper dimensions.

Figure 3
Image classifier interface with high-confidence predictions

In Figure 3, the image shows a web application of an image classifier that allows the user to select and upload image files. Two examples present classification results: one predicts "shoes" with a confidence of 99.99%, and another predicts "t-shirt" with a confidence level of 99.99%. Both predictions indicate that the model has a high degree of accuracy in its classifications.

The descriptive results of the consumer experience variable are shown below:

Table 1
Level of consumer experience

Level	Pretest VD (%)	Post-test VD (%)
Good	0%	90%
Fair	24%	10%
Poor	76%	0%

In the pretest, where the traditional system without the image classifier was evaluated, 76% of users rated their experience as Poor, and 24% as Fair, reflecting a predominantly negative perception and low satisfaction with the system. However, in the posttest, after implementing the image classifier, 90% of users rated their experience as Good, while only 10% considered it Fair, with no negative ratings recorded.

Table 2
Wilcoxon signed-rank test for consumer behavior among university students

Null Hypothesis	Test	Sig. a, b	Decision
The median of differences between Consumer Experience - Pretest and Consumer Experience - Posttest is equal to 0.	Wilcoxon signed-rank test for related samples	0.000	Reject the null hypothesis.

Note. A. The significance level is 0.050. B. Asymptotic significance is shown.

The Wilcoxon signed-rank test was applied to evaluate the differences in consumer behavior before and after using the image classifier, obtaining a significance value of 0.000, which is less than 0.050. This led to the

rejection of the null hypothesis (H0), evidencing that the image classifier based on neural networks improves consumer behavior among university students. The observed difference is not random but a real change in consumer interaction and decisions following the application of the classifier.

Regarding the discussion of results, we can note that in relation to the general objective of this research, which was to determine how the image classifier based on neural networks (ANN) improves consumer behavior among university students, the results indicate a significant effect. The Wilcoxon rank test yielded a significance value of 0.000, confirming that the observed change is not random but directly attributable to the technological intervention. This finding supports the results of Briones (2020), who emphasized the importance of customer experience in satisfaction; although his research focused on shopping centers, this study extends this perspective to the context of consumption decisions among university students, specifically in interaction with image classification technology.

Finally, the use of dense and convolutional neural networks (VGG16) demonstrated high accuracy in image classification, highlighting techniques such as normalization, data augmentation, and visual analysis. These results are consistent with those found by Alipour (2024), who tested CNNs with data from various sources and emphasized the importance of appropriately selecting data features. The high accuracy achieved in our ANN model reinforces the validity of these findings, highlighting precise classification as a transcendent factor for improving trust in the model and, consequently, the consumer experience on digital platforms.

Conclusions

Regarding the application of the image classifier model based on Convolutional Neural Networks (CNN) for retail, the pre-trained VGG16 architecture was used as a foundation. This configuration allowed for the utilization of advanced features in image processing, significantly enhancing the model's performance. Additionally, data augmentation techniques, such as rotation, shifting, and zooming, were applied to optimize the model's ability to generalize and adapt to variations in images. The model, trained with 625 images across four product categories (bags, shoes, pants, and t-shirts), achieved high accuracy in predictions, stopping automatically upon reaching the best possible accuracy. In the testing phase, the model classified new product images with a high level of confidence, allowing for specific label suggestions for each retail product category.

The Wilcoxon signed-rank test yielded a significance value of 0.000, leading to the rejection of the null hypothesis. This demonstrates that the observed changes in motivation, perception, learning, and attitude of students were not random but directly attributed to the implementation of the image classifier. The pre-trained VGG16 architecture of convolutional neural networks was utilized, applying data augmentation techniques to enhance model performance. The model achieved high accuracy in classifying four product categories, proving effective in suggesting labels within a retail context.

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