A Research on Image Processing in Modern E-commerce

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Abstract. E-commerce has transformed the retail industry due to its convenience in customization and scalability. Researchers and analysts are deploying machine learning and especially image processing onto E-commerce to visually satisfy customers. This paper explains the most significant application of image processing in E-commerce, the recommendation systems. Recommendation systems convert a product's features into many feature vectors and apply networks to filter the products. Therefore, E-commerce merchants study the recommendation algorithms and refine their image selections in product display. This paper also lists E-commerce's potential security concerns regarding image thievery and bot spamming and the application of image processing in solutions to the problems. Aside from current implications, this paper introduces direct interaction between image processing and E-commerce customers in examples like Augmented Reality and Virtual Reality, explaining their effects in enriching an interactive customer experience. In conclusion, this paper proposes the current trend and prospects for future developments in image processing in E-commerce.

Keywords: Convolutional neural networks, Digital watermarking, Augmented reality, virtual reality

1 Introduction

Exchange serves as a foundation of our society. People exchange their products and services in the form of other items but mostly currency. A society with a stable currency and exchange system enables its citizens to divide labor and optimally increase output effectively. Developments in technology, especially E-commerce reshaped the retail system. E-commerce platforms allow their users to browse thousands of goods without physically being in the store. Moreover, quick transactions and automatic scaling, ordering, and maintainability made E-commerce a favor over traditional physical stores to customers and merchants. Images play a critical role in E-commerce as they're visually appealing over plain text and are often the customer's first impression of a product [1]. A product's images provide important context and appropriate use of images builds trust between customers and merchants.

To showcase the most beautiful picture of a product, image processing plays a critical role in E-commerce merchants. However, manipulating images raises potential security concerns and is often overlooked by customers. This paper aims to explain the

B. H. Ahmad (ed.), *Proceedings of the 2023 International Conference on Data Science, Advanced Algorithm and Intelligent Computing (DAI 2023)*, Advances in Intelligent Systems Research 180,
https://doi.org/10.2991/978-94-6463-370-2_46

implication of Image Processing in Modern E-commerce, analyze E-commerce security concerns and respective solutions, and point out the potential future direction of E-commerce.

2 Current Implication: Recommendation Systems

One of the biggest advantages of e-commerce compared to brick-and-mortar is convenience. Instead of manually reviewing the store's catalog, shoppers can easily find their desired items online by searching and filtering. One of the most essential features of e-commerce is recommendation systems. Many E-commerce stores sell on platforms like Amazon or eBay, and recommendation is a critical driver for consumer adoption.

Image processing plays an important role in modern e-commerce recommendation systems. For instance, customers can use their cameras to scan the items in real life for products online [2]. When customers are interested in certain products, they are instantly recommended other products with similar looks and features [1]. Researchers showed massive interest in the recommendation system of e-commerce in the late 2010s. Earlier researchers Chaudhuri et al proposed a product image selection system that collects images from various sources and classifies them. The system then checks for image quality such as blurriness, resolution, or law issues, and reclassifies them by viewpoints. After deduplication and reordering the images, the system selects appropriate images, which positively affects conversion and add-to-cart [1].

Modern recommendation systems incorporate machine learning algorithms and AI to quantify images into computing inputs. When put into a multidimensional space, images are turned into portable feature vectors, which contain their information to be used to make predictions [3]. Machine Learning training about feature vectors can be done in many distinct ways, one example is the Siamese neural network, which compares the two networks' similarities. In application, the Siamese neural network generates two sets of input images, one similar and one dissimilar. This training aims to introduce the individual weights of a feature to the recommendation system for examination [3].

Another popular machine learning algorithm in recommendation systems is the Convolutional neural network (CNN), used in fields such as image feature extraction and Content-Based Image Retrieval (CBIR). CNN combines single features (edges, corners) and forms high-level abstract features (colors, styles). CNN also fine-tunes high-level features, reduces the operation’s dimensions, and allows less costly image classification. These high-level features are stored in hash, enabling efficient feature-utilized search [4].

A recommendation system is an essential feature of e-commerce. The recommendation system improves customer experience by analyzing customers' behavior inside the network and personalized item catalogs based on customer preference, which saves decision time and smoothens customers' shopping experience. E-commerce merchants can benefit from increased conversion rates and customer retention when appropriately applying a recommendation system.

3 Security Concerns for Image Forgery and Thievery: Image Authentication

Chaudhuri's image selection system demonstrated significant potential in E-commerce but also raised concerns such as image thief or image authentication. If a merchant gains access to the image database, they may use images from other merchants in the database to create a more optimal product representation [1].

One way to solve this problem with image processing is digital watermarking. The simplest way to prove ownership of an image by digital watermarking is to modify image pixels but this can be countered by simply cropping the image. Thus, Hsieh and Tseng proposed a way of watermarking by embedding gray-level watermarks, making the watermark resistant to various forms of image processing [5].

Hashing is a computer algorithm that generates independent hash values for each variable with unique, machine-generated hashing functions. However, simple hashing is easily manipulated, so researchers work on encrypted hashing techniques. Similar to how CNN extracts image features, hashing functions generate a randomized hash value from the item's image content to protect images from malicious attacks. Authentications of hashed images can detect and modify the image and ensure originality [6]. Researchers developed this approach with machine learning techniques to achieve deep-hashing, automatically generating unique hashing algorithms for each independent task. Moreover, deep-hashing can be used with CNN sampling layers to enhance the authentication system, enabling self-sufficient authentication without human intervention [6].

Image metadata is the embedded information of the image file. Researchers can analyze image metadata to gather information such as image compression software, compression date, and modification date. Further analysis of these parameters such as the image thumbnail's pixels and pre-extracted data can effectively identify an image and its processes [7]. Not only the image itself, but researchers can also use machine learning to analyze image metadata such as the sun's altitude angle, humidity, temperature, and camera traces to gain information that is not related to the image itself [7].

Although images can be easily forged and stolen on the internet, computer scientists and researchers developed many methods to defend image owner's intelligent properties: Digital watermarking modifies image pixels to label ownership, computer-generated hashing creates unique algorithms for each step in the processing of image authentication processes such as encryption, storage, retrieval, and authentication. Image metadata reveals embedded information about the image that can be processed to gain critical information about ownership. These methods serve as a fort for e-commerce products and ensure the legitimacy of recommendation systems.

4 Security Concerns from Malicious Users: CAPTCHA

Automation provides great convenience to its users but also raises security concerns. A bot - short for robot, is a portrayal of online automation. Bot automates its user's commands but also creates inconvenience in e-commerce. For instance, a bot that keeps

creating accounts can bring a significant amount of useless data and storage pressure, slowing down the whole website [8]. More importantly, bots generate more traffic than humans, potentially creating false orders or reviews that disrupt a particular merchant or even the whole website. Therefore, computer scientists introduced CAPTCHA (Completely Automated Public Turing test to tell Computers and Humans Apart) (Fig. 1) to secure the website from malicious behaviors.

Fig. 1. CAPTCHA [9]

Through various forms of image processing, CAPTCHA degrades a randomized key to make computers unable to recognize. E-commerce websites can insert a CAPTCHA before actions such as login or purchase to ensure the action is operated by a real human [10].

Many researchers aim to challenge CAPTCHA with bots by machine learning. One approach is using the CNN, which transfers the color perception of an image into channels of red, green, and blue. Training in separate color channels significantly increases the model's recognition accuracy [8].

Another approach is Random Forest, which puts a bigger emphasis on image processing. Kong and Chang proposed a way to "revert" the colored images to black and white. By converting every colored pixel to Grayscale, researchers reduced the colored pixels' variables from red, green, and blue to only gray. After filtering out image noises with the Gaussian filtering method, the images were further processed to only black (if gray > 155) and white [11]. These image-processing techniques downgraded the processing challenges from three variables of 0-255 to binary computation, drastically reducing computation time and cost. Moreover, Kong and Chang claimed that binary computation does not require a dedicated GPU (Graphics Processing Unit), increasing the accessibility of the technique while maintaining a satisfactory result, even with a generally insufficient data size [11].

Although researchers can crack shorter CAPTCHA, their models still struggle to solve longer CAPTCHA [8,11]. However, CAPTCHA is not the most customer-

friendly for the visually impaired, and longer, harder CAPTCHA or other security systems raise accessibility problems for real users, annoyed to prove themselves human [9].

5 Future Direction: A virtual, interactive shopping adventure

A customer's shopping experience is a dynamic and complex event that ultimately leads to conversion (purchase) and retention (coming back to buy more). Although E-commerce platforms are a convenient option for customers who already have a purchase in mind, E-commerce platforms lack the immersive experience of shopping in a physical store. Researchers aim to find ways to expand and incorporate in-store attributes onto E-commerce platforms.

AR (Augmented Reality) is a combination of real and virtual elements that enables the reproduction of virtual content in 3D settings with real-time interaction. On the other hand, VR (Virtual Reality) aims to recreate a virtual-element-only 3D environment for users [12]. AR applications do not require a specific device and can be applied to various types of personal devices, making AR relatively more accessible to customers than VR. Researcher Kowalczuk proposed a Conceptual Model (Fig. 2) to list AR characteristics that ultimately boost customers' responses in a shopping experience. Kowalczuk conducted a survey with Mobile AR applications to discover that products using AR are superior to products using websites in terms of immersion and enjoyment [13].

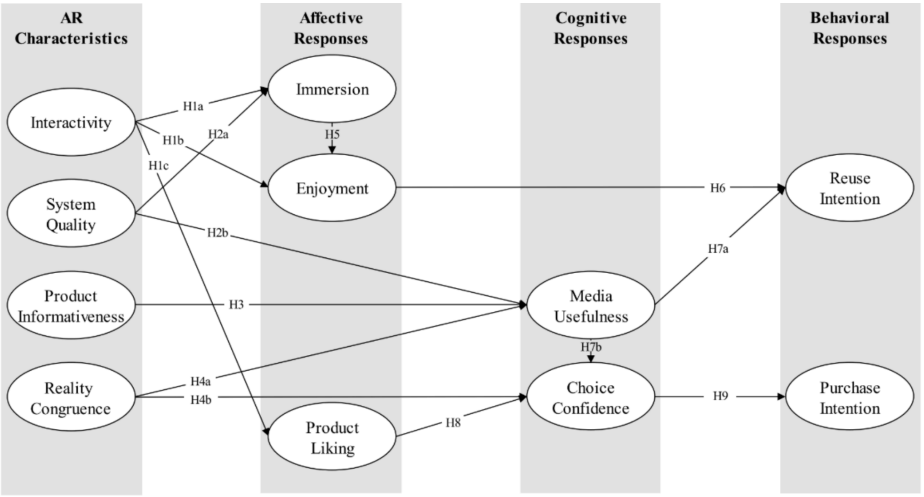

Fig. 2. Conceptual Model by Kowalczuk et al. [13]

In E-commerce, AR uses dynamic contextualization of image processing to render 3D visualizations of products that are responsive to user interactions. Current AR applications render products in customers' homes: shoe brands like Converse incorporate AR to let their users see their shoes and walk within the customer's personal device. Aside

from enhancing customer experience, AR saves the shipping cost of returns created from size and measurement mistakes [12].

Billewar et al. mentioned one potential benefit of AR-based advertisement in computer games. E-commerce merchants can take advantage of the power of community and rendering engines in games to advertise their products in-game. With image processing and rendering, merchants can extend or even create new products, drawing customers' attention with advertising before the manufacturing of the product's prototype [12]. Although VR is relatively less accessible than AR, technological advancement may bring the wishful thinking of a "metaverse" in real life. Current VR development suffers from limitations such as built environment and hazard effects on current users. These recognized problems are expected to be tackled by companies and researchers in the future [14]. With examples like NFT (Non-fungible Token) blockchain assets, VR can achieve a decentralized, intermediary-less, and secured E-commerce environment that functions in the virtual world, with products and services overcoming many real world' physical constraints [15].

The development of AR intertwines computer graphics with the real world to create a more immersive shopping experience, bringing many benefits while enriching customer satisfaction. Using AR to sell products in online games virtually extends E-commerce's advertisement and retail location. As technology advances, Researchers expect to conquer VR's "blind spot" [14], and further extend AR's achievement, revolutionizing the retail industry and achieving E-commerce in another reality.

6 Conclusion

This paper explains the importance of image processing in modern E-commerce platforms by highlighting recommendation systems. Image processing can generate a more favorable image of a product, gaining customer interest and building brand loyalty. This paper explained the various implications of image processing in an image authentication system, simplifying the complex nature of image authentication in watermarking, hashing, and metadata tracking. This paper demonstrated image processing's implication for the CAPTCHA system by explaining its role in safeguarding an e-commerce platform while pointing out several ways to attack CAPTCHA and stressing the importance of building robust security systems for a website. As the technology for computer graphics and rendering advances, this paper attempts to map the future of image processing in E-commerce. Advanced image processing technologies work together to build customers an immersive, adventurous journey shopping experience in different realities that can be accessed anywhere at any time, allowing E-commerce to completely replace traditional brick-and-mortar shopping with E-commerce's superior automatable and customizable features.

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