ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 10, Issue 4, April 2023

Product Classification using Deep Learning

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ABSTRACT: Due to dynamic and uncooperative market it has become very difficult to develop the products that are highly appreciated and loved by the consumers, due to which it has become a major issue to develop the product based on the likes and usage of the consumer rather than the intuition of the designer of the product. Understanding a product's nature and purpose in-depth is the first stage in product creation. After that, the product is categorized according to that category. Traditional product classification mainly concentrates on the market and product that designers build based on the products of previous dynasties, which may not be able to catch the attention of the customer of the present generation. Mainly consumers look for product with unique design, characteristics, functionality and many more which won't be achieved using traditional methods, hence usage of Artificial Intelligence is made in many different fields including product classification. Researchers basically face the major problem about how to apply machine learning classification concept for product classification. In this paper, a fast and effective method is proposed which can classify the product based on its feature and design patterns. It is basically a fusion of image classification with machine learning technologies. The proposed model is basically divided into three major parts: target feature is the model developed sing deep learning technologies which can extract the feature of the product, modelling is basically done to train the model which is able to predict the product based on the features extracted and train model and error analysis, to properly understand the prediction rate of the model and analyse it. This method is basically novel attempt where product design feature are train to predict the model of the new product, which basically deliver a strong application prospect.

KEYWORDS: Image classification, CNN, Product Classification, Product Design, Ergonomics

I.INTRODUCTION

With high competition in the market for product the first thing that attracts the consumer is the attractive and uniqueness of the product. Hence, the time it takes for a new product to go from design and production to the final launch of the product in the market often determines the sales and the profitability of the produced product [1].

So basically, to speed up the production process, the designer after getting the idea about the product starts designing the product based on the design categories of the new product. This further leads to designing of the product based on the general characteristics. Therefore, product classification is crucial to the design process[2, 3].

In traditional method the product classification is basically done just by modifying the product with minute changes leading to the less uniqueness of the product [4,5]. Furthermore, the complete control of the product design process is under the designer who just design the product, based on the ideas and further proceeds to the production process. Even after the designing process the production process is labour-consuming and inefficient because the product has been designed based on the designer perspective of the product rather than user perspective [6-10]. Hence in this paper a new method is proposed where the product is predicted based on its feature using the fusion of Image Classification and machine learning technologies.

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Though it may be possible that traditional methods may include Machine Learning Technologies or 3D design but there is no guarantee that the product designed will be liked by the user and product belongs to that class or company. As a result, it will become labour-consuming and ineffective leading to wastage of time and resources [11-13]. Additionally, the designed product results are not accurate and leading to inefficient development of the product [14,15].

Due to this reason, to improve the accuracy as well as help the designer to classify the product easily usage of modern machine learning technologies is used which is basically fusion of the 2 or more related technologies working together.

The most popular approach among the ML techniques used in the design areas is image classification. A computer can do categorization tasks by learning from the supplied data. The deep learning algorithms, however, require high-definition photos as the input and take a very long time to extract complicated characteristics [16]. For instance, the training procedure for the ResNet 18 common network structure uses a lot of memory and time to analyse the 3-channels colour input picture with a resolution of (224,224).

Additionally, the suggested methodology won't work if the designer has the freedom to choose the train images on his own. Using user-defined data in the model is the best way to make the method operate quickly and efficiently. However, it can be challenging to gather consumer data due to privacy concerns, and it can be challenging to guarantee the quality of survey data. This study will process a model that can extract features from the user-purchased products and categorise them in order to tackle the aforementioned challenge. The model can be strengthened in this way, but it takes time.

The proposed model can predict the product based on the features (texture) of the product and based on this the model is train which further is effective to test the product based on the model classification result. This model makes use of the most common classification method i.e. image classification is a supervised learning problem: define a train dataset to train the model and test dataset for result analysis.

II. RELATED WORKS

Classifying the new product is the first phase in the product development process, which involves defining the nature and purpose of the product [3][4][5]. The term "product classification" refers to the process of grouping things into organised categories by categorising them based on particular traits or qualities. Numerous studies and organisations have advanced the theory and method of product classification in order to serve a variety of purposes. In general, there are several informal systems of product classification developed by various industry organisations in addition to a standardised system.

[1] Tatikondaand et.al. By using more in-depth operationalizations of technology novelty and project complexity, analysing these operationalizations in conjunction with various project success outcomes, and using a large cross-sectional sample of assembled goods, this paper adds to the body of literature on project task characteristics and project outcomes. Studies on project tasks and project results sometimes concentrate only on time-related results rather than a variety of project execution results. The main issue with this approach is that it can only be used for small projects, one business, or one sector. Numerous researchers attempt to cross-company, but they do not take into account multiple execution.

Summary: It’s a novel method where project task characteristics are basically operationalized in conjunction with multiple project success outcomes on cross-sectional sample of goods.

[2] Luh et.al. This paper proposes a method to design the product based on the consumer behaviour toward a product. However, it is generally acknowledged that consumer cognitions and behaviour are fluid and unseasoned. It's important to understand how to get user feedback on a product and use it to inform the creation of prototypes. The goal of this study is to create an Empathic Design Model that can identify the cognitive orientation of consumers. This EDM model is basically determines the product based on the consumers cognition information provided to it in the form of array of

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International Journal of Advanced Research in Science, Engineering and Technology
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information. The main disadvantage of this approach is that analysts and developers have a tendency to gather an enormous quantity of general consumer data while creating a new, large-scale, sophisticated system, believing that doing so will allow them to understand market demand. Such information, however, can only be hypothetical and has a number of additional limitations, eventually just identifying the beginnings of those aspects that are most significant.

Summary: It's a novel attempt where product development is done based on the consumer cognitions towards a product and using it to develop EDM.

[3] Gutman et.al. This paper proposes a model that is based on two fundamental assumptions about consumer behaviour: (1) that values, here defined as desirable end-states of existence, dominate in guiding choice patterns; and (2) that people deal with the enormous diversity of products that are potentially satisfying their values by grouping them into sets or classes in order to reduce the complexity of choice. This implies that in addition to the product-class types of product categories, such as toothpaste, tooth brushes, chewing gum, etc., consumers can establish categories depending on the consumer that may have enormous classes.

Summary: Based on the consumer behavior towards a product leading to determining the consequences and categorization of the product.

[4] Gutmanand et.al This paper proposes a method to understand the consumer cognitive behaviour towards a product for its development. The model is efficient and easy to understand and further provides a proper understanding information about the product from user perspective. The major drawback is it require high computational power and well-designed datasets.

Summary: Novel attempt development of product based on the human connection with the product.

[5] Pieters et.al. The model put forward in this study is an innovative effort that categorises the product according to the intended consumer. MdmNet is essentially a merger of target consumer modelling and image categorization. This MdmNet is a fresh endeavour in which the incentives, willingness, and expectations of the user are used to build and develop the products. The main benefit of this technique is that it enhances classification effects by modelling target users and anticipating their mental processes. The main disadvantages are that (1) photos are not scaled and grayscale, and (2) practical implementation requires more processing power and greater resources.

Summary: Novel attempt that is basically a fusion of Image classification and target consumer modelling called MdmNet. This MdmNet is a novel attempt where the products are designed and developed based on the consumers incentives, willingness and expectations.

[6] Sun et.al. This paper proposes a proof-of-prototype concept where the proper product is developed first based on the designer perspective and further launched into the market as a prototype for trial run for reviewing and understanding the usage effect on the current market. The prototype is developed using a streamlined and well organized designing process for proper function and working of the product by users. The major drawback of this process is it developed independent of the consumer point of view hence leading to failure of the product in the current market trends.

Summary: Well defined process for development of the product through the feedback received from the prototype.

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III.METHODOLOGY

A. Data Preprocessing:

Pre-processing is the primary step that removes the noise from the raw data [19].The proposed method in this paper is primarily a novel attempt but we can't say it's new. In modern times the method is used but with modifications or other parameters taken into consideration. The proposed method is basically a fusion of image classification and machine learning technologies. Before moving into model development, the images are extracted based on the product which needs to be classified.

The train images are extracted from consumer history i.e., the product bought by them before or the interesting product model. This provides the development of the model based on the consumers perspective. The next step is to make the images grayscale and resized to make the images look more refractive. The model doesn't need the color of the product so the gray scaling of the image provides an extra edge with respect to other images and even reduces the computational power. The images are even resized in the size of (120, 120) to make sure all the images are of same size, intensity and dimension.

The grayscales images are further stored into different classes based on the product model name. Here to understand the proper effect of the model and learn about the effectiveness of the model standard cars dataset is used which has over 3325 images classified into 7 classes of different model names.

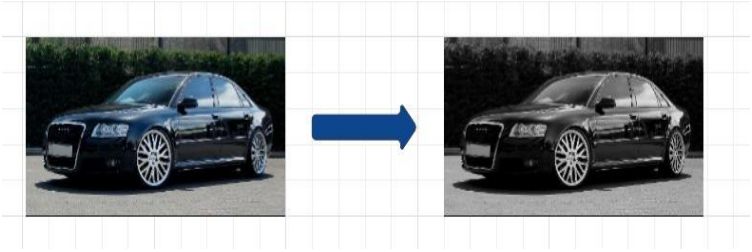

Fig 1. Grayscaling and resizing

B. Image Classification Model:

The next step in the proposed method is to develop the model which can train the images which are grayscale and resized and stored into different classes. The next step is to generate the train dataset which has access to all the images present for training the model. An additional object to keep the train generator for training the model based on the product for training the model.

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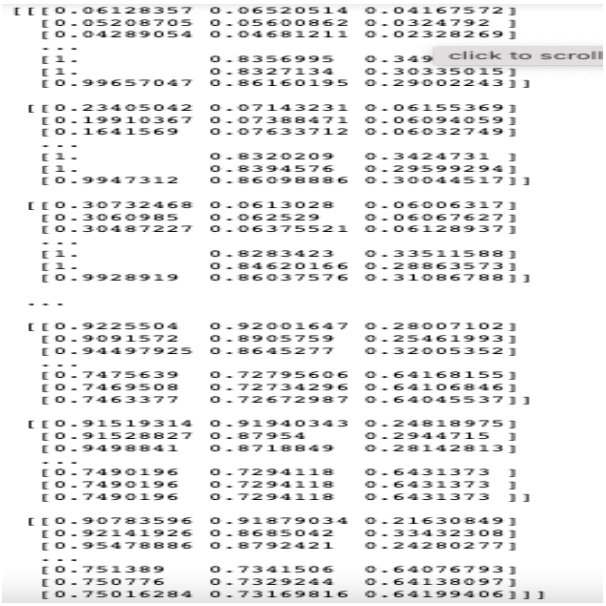

Fig 2. Batch Feature Extraction

Based on the train generator the next step is to extract batch feature about the product on different classes and store them in the array form. The batch features are extracted from the images. The images are grayscale and resized along with stored into different classes. The images in each batch of (50 x 50) consisting of 105 images are stored in the form of array. Here to properly understand we have made use of Stanford cars dataset which has about 7 classes extracting the features based on the texture and design of the product and storing them in the form of array.

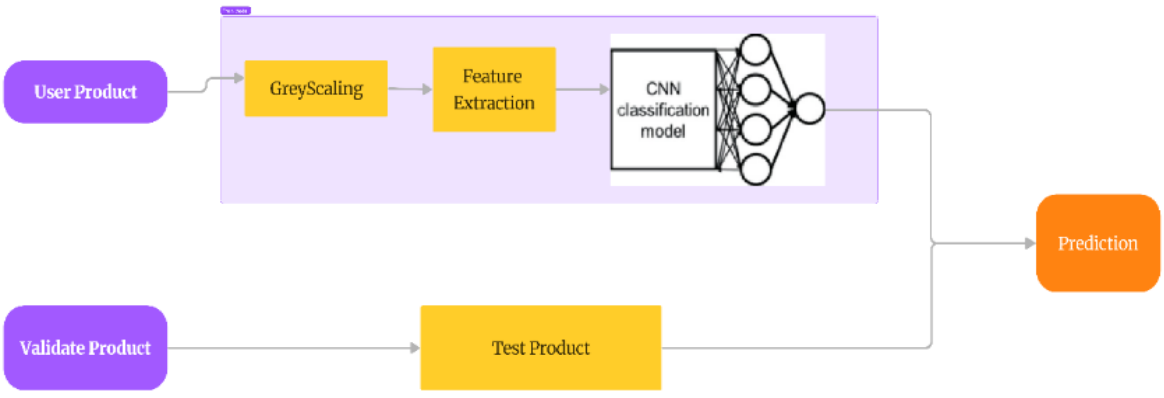

Fig 3. Architectural Design

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International Journal of Advanced Research in Science, Engineering and Technology
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The model is developed based on a total of 2,778,375 params where all are trainable based on these params the model is developed. The model is fused with the features extracted to form a classified structure where the model is train in the batch for 50 for 105 images each and for 50 epochs. Moreover, the trained model for each epoch produced accuracy value (0.24 – 0.94) along with loss value (1.7 – 1.0) in the decimal format which is used to determine the test accuracy.

C. Classifier:

The Classifier is the main part of the complete model for obtaining the result. Based on the train model and images the model can provide the accuracy using different classification algorithm. Here for the proper working of the model we have used Stanford Cars Dataset. To understand more about the classification of the product based on the customer incentive and willingness to buy the product first step is to thoroughly train the model in different batch . The train model is made to train the images in the batch of (105 x 105) for 50 different batch on different model of car. Each batch consists of 105 images of the car belonging to the same model so in order to avoid any kind mix-up they are reduced in density, colour contraction and normalized.

To make classification judgments that simulate designers, we utilize a CNN-based model trained on past purchase library data. The backbone network employed in this study is ResNet 18, and the learning rate is set at 0.001. Additionally, the loss function used is the cross-entropy loss function.

IV. RESULT AND ANALYSIS

A. Dataset:

The dataset known as Stanford Cars [12] comprises 5,025 pictures of 7 different categories of cars. The dataset has been divided into 3,325 training images and 1,700 testing images, with each category being approximately split into 60% for training and 40% for testing. The classes in the dataset generally pertain to the Make, Model, Year of the car, for instance, 2012 Tesla Model S or 2012 BMW M3 coupe. Our experiment requires three types of data from the dataset. These are: one image from the test set representing a new product, all images from the training set forming the user's last purchase library, and randomly selected target consumer expectations from each class in the test set.

B. Classification Result:

To enhance the comprehensibility of the classification results, we adopt the product itself, instead of the class label, as the representation of the results.

The process begins by feeding the new product into the system. Through a comparison of its similarity with the target consumers' expectations, the system provides classification results from the consumers' perspective, represented in the consumer's rank. On the other hand, by utilizing the data in the past library [4][16], the system provides classification results from the designer's perspective. The final output is determined by combining the results from both perspectives.

To facilitate the designer's understanding of the new product and its design, we employ a CNN-based model to simulate the designer's classification judgment, with training data drawn from the users' past purchase library. In this study, ResNet 18 serves as the backbone network, with a learning rate of 0.001 and a cross-entropy loss function.

The classification result indicates the class to which the test product belongs, providing the designer with valuable insights into the new product.

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International Journal of Advanced Research in Science, Engineering and Technology
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Fig 4, Classification Predict Result

As mentioned in figure 5, the training model provides the accuracy of (0.9) ranging from (0.3 – 0.9) for a total of 50 epochs where each batch of epoch has a total of 1055 images being trained. This provides a proof about the training accuracy by the training images used for training the model. The training loss is even calculates based on each epoch to understand the accurate loss obtained in each epoch. The figure 6, provides a proof about the training loss about the train data provided.

Furthermore, the validation accuracy is calculated for each image based on the train model developed. The train model is able to determine the similarity between the validate product or new product passed as input by the designer. This model is able to determine the product based on the train model by defining the similarity between two product and gives the result in the form of class name the product as shown in fig 4, belongs to along with the confidence percent to understand the level to which the model is able to understand new product.

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International Journal of Advanced Research in Science, Engineering and Technology
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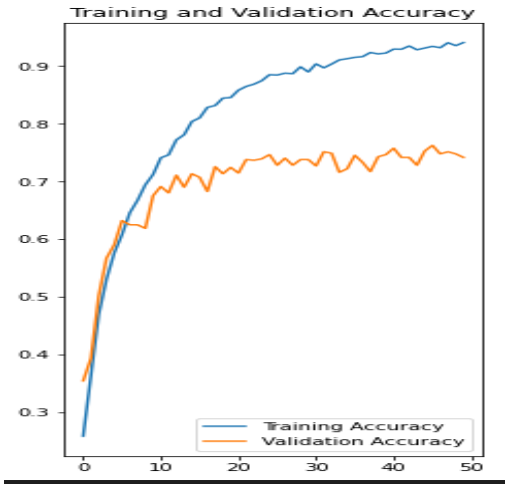

Fig 5. Training and Validation Accuracy

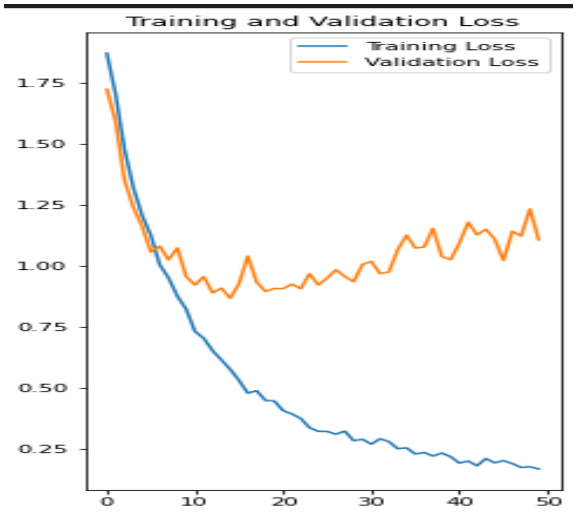

Fig 6. Training and Validation Loss

V. CONCLUSION

Previously, businesses had to produce products in large quantities and keep significant inventory to meet the demands of target consumers. However, modern businesses require greater flexibility in their design and production processes to adapt to the rapidly changing market conditions. This paper presents a new approach that incorporates product features with image classification to achieve fast and efficient product classification. The approach comprises batch feature extraction and image classification. The experiments conducted on the benchmark Cars Dataset showcase the excellent performance of the proposed method.

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