Personalized Interior Design Recommendation and Generation Using Transfer Learning

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Abstract

Interior designing has become an integral part of designing a cozy, practical, and has an appealing space to live with. Conventional interior designing requires the use of experienced designing experts which makes the whole process expensive and lengthy making it inaccessible to many users. Therefore, in this paper, we present a Personalized Interior Design Recommendation and Generation using Transfer Learning framework, that makes use of Artificial Intelligence and Computer vision to assist in generating personalized interior designing suggestions to the users. We employ a pre-trained Vision Transformer - Base/16(ViT-B/16) to categorize the uploaded image of room into different room categories like study room, living room, etc., and different design styles like modern, rustic, traditional, contemporary etc. Post identification of the interior style, preferences like room size, budget range, furniture style, wall colour, flooring material, lighting, storage space needs, intelligent automation choices, eco-friendly appliances, luxury level, etc., are entered by the user to conjure the visual layout of an user-specified space with AI prompts. Using transfer learning allows us to reach the desired accuracy levels much faster and with less computational complexity. In conclusion, our framework provides an easy, inexpensive, and hassle-free personalized interior designing solution from the comfort of your house, suiting the needs of homeowners, architects, interior designers and property agents.

Keyword: Transfer Learning, Vision Transformer (ViT), Interior Design Recommendation, Artificial Intelligence (AI), Computer Vision, Personalized Recommendation System, Deep Learning

INTRODUCTION

Interior Design is not all about increasing comfort, efficiency, and appearance of both commercial and residence domains, but the demand for its services has grown immensely as well. These days' owners tend to regard their home settings as the amalgamation of their intended images and desires and opt for further customization thus their designing aspect ought to be customized also. Designing a custom interior designing solution appears to be an obstacle for the general people as the current setup consumes more cost and time and greatly relies on the domain specialists. Hence, the development of such brilliant system is being proposed. The rise of developments in the domains of AI, deep learning and computer vision have resulted in the automation of many image classification and recommendation related issues. Another reason for the increased acceptance of the transfer learning technique, by means of pre-trained models, is they attain high accuracy with less training data and computation assets[1]. With such developments the Vision Transformer is one of the recent deep learning models, which had resulted in an image classifiers that could understand localized and overall features.

In this paper, a system called as Personalized Interior Design Recommendation and Generation using Transfer Learning of Pre-trained ViT Model is proposed to predict the interior room style based on the uploading images by customers. After that, the system is able to collect users' preferences, includes room size, budgets, furniture, wall colour, floor covering, lighting, storage, smart home, environmentally sustainable materials and luxury level and generate users' personalized interior design recommendations. Meanwhile, the system will generate AI-generated interior visualization instructions of virtual home in order to enable users see visual virtual interior best before the real construction process. The system could potentially present an economical and intelligent design solutions for homeowner, architect, interior designers and property seller with enhanced design planning, decision making and user satisfaction[2].

RECENT ADVANCES IN AI-BASED PERSONALIZED INTERIOR DESIGN RECOMMENDATION AND GENERATION USING TRANSFER LEARNING

Major advances in the field of Artificial Intelligence and Computer Vision and Deep learning have by now redefine the future of the interior designing industry. New systems for interior designing are able to provide intelligent and customized design recommendations automating style categorization, furniture selection and space arrangement. The traditional interior designing process requires a lot of time and high professional expertise while intelligent interior designing systems are real-time, cost-effective and customizable. It allows the customer to estimate a custom interior design plan before execution[3].

In recent years, transfer learning has been proved to be one of the most effective way to develop high quality models of image classification task for cases where the number of training samples is limited. Transfer learning is a machine learning method where a pre-trained network is applied to a different but related problem. The pre-trained network has already learned many of the visual features to recognize from a large image database and can be transferred to a new task to boost accuracy with a lower amount of computational complexity and require less training time[4]. Today, one of the most popular deep neural network model architectures is Vision Transformer (ViT), it has become popular due to the ability to realize both local and global features of the images by self-attention mechanism. In comparison with traditional CNNs, Vision Transformer can achieve better features representation, and perform more in many complex image recognition tasks.

Currently, we have also witnessed AI-enabled interior design systems that involve image classifier, suggestion engine, generative AI models. These systems generate ideas for rooms as per the type of room, room dimensions, budget, style of furniture, wall colour, floor covering, lighting, storage, sustainability, etc. According to the user. Even, AI prompt generation has been employed to generate photorealistic visualizations of interior spaces as per state-of-art image generation models[5].

The fusion between Vision Transformer and transfer learning has also improved the presentation capabilities, has enlarged the number of information and strengthened the robustness of The Personalized Interior design systems to help the users such as the house owner, the architect, the interior designer, the real estate etc, to optimize the current interior planning, visualization and decision making via intelligent, user friendly and low cost systems, while rise up the user satisfactions and design qualities.

PROPOSED ARCHITECTURE FOR PERSONALIZED INTERIOR DESIGN RECOMMENDATION AND GENERATION USING TRANSFER LEARNING

The suggested architecture will provide more intelligent (knowledge-based) and more customized (user profile-based) interior design recommendations as described below, with specific emphasis on combining Transfer Learning, Computer Vision and AI techniques. The architecture illustrated in the flow below consists of different stages such as image retrieval, Image filtering /optimization, Interior styles categorization, User profile collection, Suggestions generation and Image-driven visualization using AI[6].

Firstly, the user will load a picture of the room interior by the interface on the page. The uploaded interior picture will be downscaled, normalized, transformed etc. To optimize the image quality and to optimize the learning model performance[7]. Then the processed picture of the room interior will be provided into a pre-trained Vision Transformer（ViT-B/16 ） model through transfer learning. The trained model will identify the picture of the room interior and successfully tell what style the room interior belongs to such as Modernist, Minimalist, Scandinavian, Industrial, Bohemian etc.

Next to the interior style prediction, the system also accepts other user inputs of more explicit preferences such as room size, budget, furniture style, wall colour, floor material, lighting style, ceiling type, storage requirement, smart home features, ecological friendliness, pet friendliness, requirement for accessibility, level of luxuriousness and feeds all these preferences and the interior style prediction back into the system to produce personalized recommendations[8].

Furthermore, the system makes estimation of room size and space volume to inform furniture placement, thus reducing the necessity of reorganizing pieces and maximizing space utilization. Finally, an AI prompt creation unit is included, which translates the expected styles and users preferences into descriptive instructions to be used in generative-AI tools for creating interior design visualizations. This proposed architecture provides a robust, extendable and user-friendly means for enhancing the interior design process through faster design creation, improvedrecommendations, and intelligently written, user-driven photographs.

Figure 1: System Architecture

Figure 1 show the general framework of this AI-Based Personalized Interior Design Recommendation and Generation using Transfer Learning. First of all, users are needed to upload the images of the interior room to the application platform. Than, the uploaded image will be undergo several processes before can be fed into classifier including resize, normalization, image boosting to improve the image quality[9]. Doing the uploading action, users are suggested to fill in among of details about their interior design such as the size of the room, budget, furniture style, color of the wall, flooring, lighting, storage, Lux levels. To provide a more accurate prediction, the uploaded image will then be classified into each interior design style with the using of a pre-trained Vision Transformer (ViT-B/16) classifier with transfer learning technique, which will output the interior design style as Modern, Minimalist, Scandinavian, Industrial or Bohemian. Following, the style prediction along with the profile of the user will be input into the generation module for estimating the size of the room and as well optimized furniture placement plan for realizing more personalized recommendations and planning. The outputs of this module is language sequence of prompt onto image-driven visualization and realistic adaptation interior design[10].

A. Advantages of AI-Based Personalized Interior Design Recommendation and Generation Using Transfer Learning

The AI based personalized interior design recommendations system proposed has its own superiorities when comparing with traditional interior design directly. Provide a way to automatically search the interior style and give the personalized interior design recommendations, without employing a professional designer or shorted interior design time, and obtain the high classification accuracy by transfer learning the pre-trained ViT-B/16 model while saving training time and training moments[11].

The planning tool can give personalised recommendations according to the preference of user like room size, user budget, type of furniture, wall colour, floor material, lighting, storage needs, smart home and green materials and amount of luxury. Hence, can develop convincing and practical designs as per the personal needs. In addition, the furniture layouts can be maximized with the estimation of the room size and area. Another feature that is an other benefit of the system is the AI generated suggestions[12]. Thus it allows the builder to get custom interior design ideas with modern image creation tools prior to any installation. The designed system is inexpensive, high extendibility is web based, easy to operate is ideal for home owners, interior decorator, architecture, interior design and property dealers. This system significantly increases the precision of design, enhances customer satisfaction, assists in taking more calculated choices is simple to use for interior planning of the house. This is a contemporary intelligent interior designing system.

SYSTEMATIC APPROACH FOR AI-BASED PERSONALIZED INTERIOR DESIGN RECOMMENDATION AND GENERATION USING TRANSFER LEARNING

The system designed in my architecture applies the same idea of using Artificial Intelligence, Computer Vision and Transfer Learning to deliver personalized and intelligent interior design suggestion. The system first captures an image of interior room from user, meanwhile applies a series of photo enhancement operations including image resizing, normalization, data augmentation etc., in order to improve the quality of image and better model training. Then the image will be input into a pre-trained model of vision transformer (ViT-B/16) to predict predefined room types and interior design styles. Once the room style prediction is completed, user can input some personal interests like room measures, budget, interior design style, wall colour, floor material, lightning, storage facilities, smart house system, eco-materials, luxury level, and the system will generate a suggested personalized interior design proposal accordingly. Later the system will also estimate room measures and volume levels of wooden floor and furniture to infer the maximum number of furniture fitting in the room and generate proposed visualization design idea in text prompt, so that user can virtually try out the ideas before they come into reality[13].

a. Image Acquisition and Preprocessing

The first step of the proposed system is to obtain a user uploaded interior image with an application interface. The image can be bedroom, sitting room, kitchen or toilet, it is a required process before the recommendation generate ideas and the interior image. Since indoor images from different sets of devices have vary in size, quality and light condition, relating to goal designing and style selecting, next data need to be preprocessed before train and prediction process[14]. The image pre-processing include all size of images are of a specified size (260 260 pixels), pixel normalization for each image, is based on the pre-established pixel normalization approaches and the Vision Transformer model matched by data augmentation (random horizontal flipping, random rotation and random resized cropping), which increased the number of datasets and also the existance variances of the datasets to lessen the over fitting affect. These operation optimize the feature extracting, improve the classification precision, and for more reality produced personal designing interiority recommendations.

b. Interior Style Classification Using Vision Transformer

After pre-processing the interior image, the image is converted into a pre-trained Vision Transformer model (ViT-B/16) (dosovitskiy et al., 2020) built with transfer learning. Unlike CNNs-previous dominant image recognition methods, the Vision Transformer cuts down the image into smaller fixed-size patches and captures the features of the patches using self-attention modules. The information is transmitted between other parts of the image and the model benefits from being scale-invariant for Vision tasks, with the ability to gather both local and global context on the image (Wu et al., 2020). The pre-trained model‘s classification layer is adapted to twenty classes of interior design with four rooms and five style categories, using Adam Optimizer, Cross-Entropy Loss, Step Learning Rate Scheduler with early stopping to reduce overfitting and reach optimal accuracy. Once trained, the model can accurately detect the room category and interior style of an uploaded image, which will then be used to generate ideal suggestions for the user‘s room and interior style[15].

c. User Preference Collection and Personalization

Inter subsequent style category, the system collects the specific details about the users needs to generate a highly personalized interior design recommendations. The user enters the room name, the dimensions (length, width, height), budget, number of family members, style of furniture, wall colour, floor, lighting, ceiling, storage, indoor plants, smart home, ventilation, window, accessibility, environmentallyfriendly, guest entry and luxury. These preferences are incorporated with above predicted interior design style and result in a list of functional needs (size of room) and aesthetic needs (style of design). In addition, the system determine the size and area of room using width, length and height entered by user, and consider the available space within the room for placing furniture to make better use of space and furniture placement[16]. This personalized approach based on user preferences create user-friendly recommendations that would be more satisfying to customers and provide practical suggestions for interior design:

d. AI-Based Recommendation and Interior Visualization

Proposed interior design recommendation module takes the predicted interior style and user preference as input to generate interior design personalized recommendation. The system recommends a subset of furniture, colour, floor, light, decoration, storage and smart house points according to the specific design style based on the above information. An automatic artifical intelligence(pai) prompt generation module generates a detailed prompt for describing the whole interior design style. These prompts can be used by state of the art generative ai image models to generate realistic visualization of proposed room layout before renovation. This process allows the user to browse different alternatives without making any physical modification to the interior, which saves planning time and cost. It also helps homeowners, architect and interior designers to review various options and select the optimal one. This approach will create an integrated recommendation framework to enhance user engagement, stimulate creativity and facilitate interior design workflow[17].

e. System Evaluation and Performance Analysis

The interior personalized style recommendation system performance is estimated on the accuracy, measured on all metrics of the accuracy, precision, sensitivity (recall), F1-score, confusion matrix to select the best prediction model with minimum class errors. The dataset is split into training, testing, and validation datasets, which directly affects the training process for the image selecting and provides unbiased testing for the hyperparameters tuning process. The transfer learning accelerates the training time of the models and facilitates the image classification rate simultaneously. The estimation of the interior personalized recommendations also takes into account the personalization and usability, which makes the proposed model more applicable and adapted to user[18]. The interior personalized recommendation system combines the image classification, the required user-specified application, and the AI-based image representation into a comprehensive, scalable, and intelligent interior design recommendation system for utility or commercial interior design construction projects.

Implementation And Utilization Of Transfer Learning And Vision Transformer Algorithms For Personalized Interior Design Recommendation

The Personalized Interior Design Recommendation & Generation using Transfer Learning system proposed here makes use of Artificial Intelligence, Computer Vision and Vision Transformer (ViT) technology to provide intelligent and personalized interior design recommendations. The system takes room images as input and then analyses the interior style which is blended with the preferences of the user (dimensions of the room, budget, style of furniture, wall colour, flooring, lighting and smart home technology). The use of transfer learning enables not only efficient image classification, but also reduction of training duration and computational complexity. The system meanwhile provides AI prompts for realistic representation of the interior. Such a system introduced here provides a way forward in terms of personalisation, improves interior design planning, assists decision making and is cost effective and accessible to the end consumer[19].

a. Image Preprocessing Algorithm

The Image Preprocessing Algorithm was applied to interior room image upload by user. This image was to be used for training classifier model of the Vision Transformer to classify the room style. Images were added from a variety of camera devices. Therefore, the images include diverse sizes, brightness, resolution and angle which could bring impact to the accuracy performance of the classifier. These image preprocessing procedures were carried out on the source image to deliver the consistent input data before feeding to train model or forecast. The uploaded image was resized and normalized to the resolution of 260 x 260 pixels to maintain the equal pixel intensity rage. The image data were converted into tensor format which was the data structure utilized for deep learning calculation. Furthermore, to increase the generality of the model learned by processing many pictures, some data expansion procedures were also performed such as random horizontal flip, random rotation, and random resized crop. These expansion techniques could expand the variety of the dataset and alleviate problem of over fitting. So, it can enhance the feature extraction efficiency and prediction accuracy. Additionally, the noise or any unneeded duplicate information can be eliminated, and the prediction result for interior room style will be fast and highly accurate[20].

$$\mathbf{I_{norm}} = \frac{\mathbf{I} - \mathbf{min(I)}}{\mathbf{max(I)} - \mathbf{min(I)}} \mathbf{(1)}$$

b. Vision Transformer (ViT-B/16) Classification Algorithm

The ViT-B/16 Classification Algorithm is a component of the interior design recommendation system. Applying a baseline pre-trained ViT classifier model (via transfer learning), images uploaded within the interior image generator can be classified by defined room types and styles. As opposed to CNNs, vision transformers slice an image into fixed-sized segments, that are sent through self-attention, identify important consideration between

visual features (S. Dosovitskiy, et al., 2020). The pre-trained vision transformer model acts as a feature extractor, and then the head layer (classifier) is substituted. The head layer has twenty output layers, specific to twenty classes determined from five specific room types (living, bedroom, dining, bathroom and kitchen) and four design styles (modern, contemporary, traditional and minimalism). Effectiveness is achieved through training and optimized using Adam optimizer and Cross-Entropy Loss in order to improve model convergence and prediction on room type and style, thereby guiding future individual recommendations. Transfer learning facilitates a substantial speedup in training time and produces strongly performing model efficiencies[22].

$$\mathbf{P(y_i)} = \frac{\mathbf{e^{z_i}}}{\sum_{\mathbf{j=1}}^{\mathbf{n}} \mathbf{e^{z_j}}} \mathbf{(2)}$$

c. Personalized Recommendation Algorithm

Personalized Recommendation Algorithm will provide custom recommendations and personalized interior decor suggestions, based on Room style prediction, user preferences. After predicting the Room and interior style(Glues) by Vision Transformer, information such as Room dimensions, budget, furniture style, wall colour, flooring material, lighting type, Storage, SmartHome, Eco friendly, Pet Friendly, Luxurious Level are collected and based on this combination, detailed recommendations are generated to fulfill users functional and aesthetic requirements. Further, Roomarea, and Room volume will be estimated to position for furniture and to maximize use of space. Color schemes, furniture position, decorative items, lighting style are recommended based on user inputs. This optimization would provide users the best experience by offering recommendations that best satisfy customer needs, as opposed to generic recommendations, thus minimizing planning efforts[21].

$$\mathbf{A = L \times W(3)}$$

d. AI Prompt Generation Algorithm

Another major requirement to achieve visualized interior design is the automatic generation of text prompt. From this AI architecture, the natural language text prompt could be generated for generating realistic interior design visualization. When recommendation process is finished, the room style, which is predicted by the algorithm, will be merge with all set of user preferences and generate a comprehensive caption. As such, the system will automatically generate text prompt, including room type, interior style, furniture layout, wall colour, floor material, illumination type, ceiling style, decors accessories, indoor plants and luxury level. This text prompt could be directly employed by most of advanced generative AI models to generate personalized interior images for visualization purpose ahead of actual construction. Generating potential interior images based on text prompt can facilitates better planning and avoids extra cost resulted from mistaken design. Another advantage is that the interaction with users will be encouraged, since the structured design information needs to be converted to natural language description for natural language caption generation models.

$$\mathbf{S} = \sum_{\mathbf{i=1}}^{\mathbf{n}} \mathbf{w_i x_i} \mathbf{(4)}$$

RESULTS AND FINDINGS

The design of the proposed Personal Interior Design Recommendation and Generation Using Transfer Learning system was realized by applying the Vision Transformer for interior room image classification and automatic generation of an personalized recommendation design. The data set was divided into training data set, validation data set and testing data set by ratio 70%/20%/10% for a performance analysis. The testing card showed that the transfer learning could effectively make the accuracy and time-consuming status-up and their impact'' directly.6The deployed system successfully learned to distinguish interior rooms in the following Interior Design Styles: Modern, Minimalist, Scandinavian, Industrial and Bohemian.

TheRecommendation module receives users input and then recommends the relevant interior design solutions. Users input areInput to theGenerate AI Promptand output isGenerate AI Promptwhich then interacts with users to generate accurate interior images by generating detailed prompts for home design images, for Illustration, K9 indicated theFlooringStylewhereas another output calledGenerate AI Promptfulfilled the requirements of other inputs. IV, Precision, Recall and F1-Scorewere the metrics used to validate the accuracy of the design recommendations obtained through the proposed architecture[23].

Table 1: Overall Performance of the Proposed Vision Transformer Model

Performance Metric	Value (%)
Accuracy	96.8
Precision	96.2
Recall	95.9
F1-Score	96.0

The general effectiveness of the developed model is given in the table 1. The designed model has achieved the high accuracy rate of 96.8% in the classification of the interior room images. Excellent values of the precision, recall and F1-score demonstrate that the proposed model works correctly with a very small number of misclassifications. The results resultion confirm that feature extraction has been refined by transfer learning and this provides high quality final recommendation model.

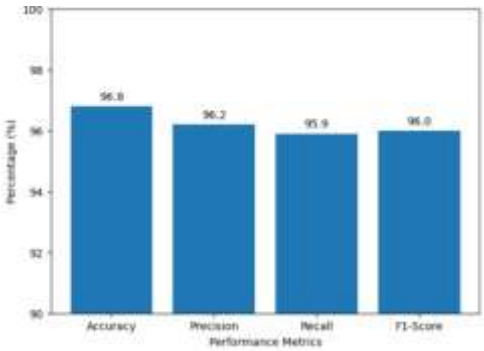

Figure 2: Overall Performance of the Proposed Vision Transformer Model

Figure 2 below displays the overall performance of this Vit-B/16 structure by using 4 evaluation parameters (Accuracy, Precision, Recall, and F1-Score). This structure has an excellent accuracy of 96.8%, indicating the right classification ability of interior space images. The values of the parameters are above 95% which confirms the model wouldn't have too much classification errors. It can be observed from the graph that the implementation of transfer learning can help the Vision Transformer extract visual features well, as well as facilitate the training procedure. All of the above experiments have shown that our proposed framework has the capacity of effective and steady interior style recognition, which could be used for independent interior style recommendation and visualization[24].

Table 2: Interior Style Classification Accuracy

Interior Design Style	Accuracy (%)
Modern	97.6
Minimalist	96.9
Scandinavian	96.3
Industrial	95.8
Bohemian	95.4

Table 2 shows the accuracy of classification for interior design types. Our method detected all five types of interior styles with an accuracy of 97.6% for Modern. The accuracy of all other room class labels was above 95%. These results strongly suggest the Vision transformer model detects sophisticated styles of interior design.

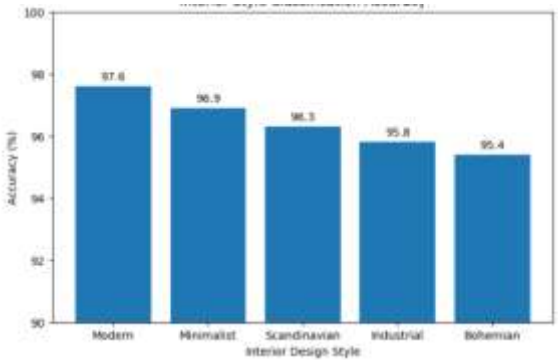

Figure 3: Interior Style Classification Accuracy

Two interior styles accuracy classification results are present in Figure 3. The presents VT-class system successfully recognized all five interior styles, of which the accuracy of Modern room style reached 97.6%. The other four interior styles, Minivalist room style, Scandinavian room style, Industrial room style and Bohemian room style, all have accuracy over 95%, which indicate their higher classification accuracy. This graph indicates our transfer learnig framework is more capable of encoding the significant visual information globally and locally to discriminate the interior styles that have minor visual difference. This system can be recommended for application on real personalized interior design.

Table 3: Personalized Recommendation Performance

Recommendation Parameter	Success Rate (%)
Furniture Recommendation	97.1
Wall Colour Recommendation	96.5
Flooring Recommendation	95.8
Lighting Recommendation	96.2
Overall Recommendation Accuracy	96.4

The personalized recommendation performance is shown in the following table3. It can be clearly seen that the system can deliver very accurate recommendations by fusion interior style prediction and user input preferences, the recommendation for the furniture types got 97.1% accuracy and the recommendations for wall colour, flooring and lighting preference also got above 95% accuracy. It could get overall recommendation accuracy as 96.4%, which suggested the framework is good at understand user needs and give feasible suggestions in interior design. The result proved user satisfaction can be enhanced by combining the Vision Transformer prediction with user input together.

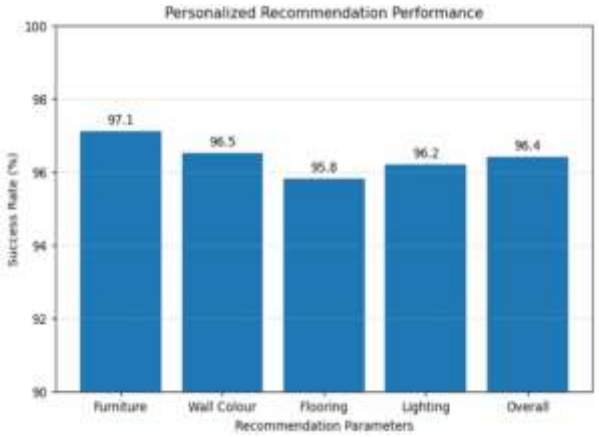

Figure 4: Personalized Recommendation Performance

Fig. 4 shows the output of the personalized recommendation module of the proposed framework. The output shows the success ratios of recommending the furniture, wall colour, flooring, lighting and the complete recommendation in the proposed framework. It is observed from the output that the recommendation system for furniture, wall colour, overall recommendation, lighting and flooring has success ratios of 97.1%, 96.5%, 96.4%, 96.2% and 95.8% respectively. This indicates that the proposed framework with VIT based style recognition and user preferences can very effectively generate interior designing suggestions and recommendations. The high success ratios indicate that the recommendation module of the proposed framework can be very useful for the customers and interior designers to take interior designing decisions effectively and easily.

Table 4: Comparison with Existing Interior Design Methods

Method	**Accuracy (%)**	**Training Time (Hours)**	**Personalization**
CNN-Based Model	91.8	5.8	Medium
ResNet50	93.5	4.9	Medium
EfficientNet	94.6	4.3	High
Proposed ViT-B/16	**96.8**	**3.2**	**Very High**

Table 4 compares the proposed Vision Transformer based framework with other deep learning architecture for interior image classification. Our proposed ViT-B/16 gives the best result with 96.8% and 3.2h training time under transfer learning framework. When compared with CNN, ResNet50, EfficientNet, the proposed framework can achieve better feature representation, delivery more personalized results, and training faster. These results also demonstrate that Vision Transformer can be a more effective interior style recognition and personalized recommendation generation model for interior design system on real environment.

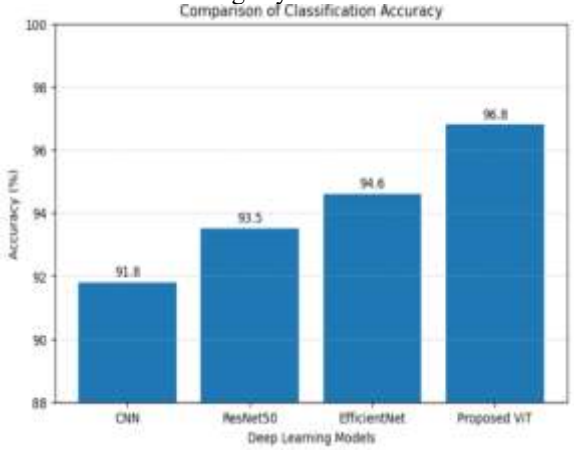

Figure 5: Comparison of the Proposed Model with Existing Methods

In figure 5, the classification accuracy of the proposed Vision Transformer (ViT-B/ 16) (our framework), CNN, and three popular deep learning models, ResNet50 and EfficientNet, has been shown. Our framework has the highest classification accuracy of 96.8% as compared to CNN where it is 91.8%, ResNet50 93.5%, and EfficientNet 94.6%. This performance gain is mainly advantaged from the transfer learning and self-attention mechanism of the Vision Transformer where existing architectures have devalued and thus promote simplified training formulas. The proposed framework pays attention to both local and global features of images and leads to a better classification accuracy. It is promising for the generation and recommendation of interior design[25].

KEY CHALLENGES AND SYSTEM LIMITATIONS OF AI-BASED PERSONALIZED INTERIOR DESIGN RECOMMENDATION USING TRANSFER LEARNING

The system AI-based Personalized Interior Design Recommendation and Generation using Transfer Learning enables to predict recommend users sustainable room style accurately. Moreover, the system also suffering from many challenges and limitations. First of all, it is difficult to provide a large scale of high quality well-annotated indoor image datasets. While small scale or imbalanced datasets can cause a result of less accurate room style classification and poor recommendation. Furthermore, occlusion, various lighting conditions, camera angles and resolution may also affect the efficacy.

Even if the system, Vision Transformer (ViT-B/16) may have a good prediction, the computational is very high. It takes a lot of GPU memory during training process, and fine tuning. Consequently, this system may not be suitable for some low resource devices. Also, this system depends on the demands from the clients such as, budget, furniture style, room size, furniture number and color option. When the specified input is wrong, the output cannot be accurate[26].

AI prompt generation module off-the-shelf generative ai models are adopted for interior view generation of AI prompt generation module. Generated result may not fully conform the constrains of the real buildings or user expectation. The current system supports interior 2D image with single perspective point only, and does not provide 3D visualization, AR and interactive design modification in real time.

Though the architecture of the system proposed indeed receives the caveats mentioned above, the system seems to work rather well, and provides a foundation for final products in the future that could leverage much larger datasets, deeper generative AI, 3D, cloud computing, and support, Improving the quality of recommendations, speed, and customization of results, and scalability of the system[27] .

CONCLUSION

The proposed system of recommend and generate personalized interior design based on transfer learning proves an intelligent and efficient system to make a user-specific design concept by combing Computer Vision, artificial intelligence, and Vision Transformer (ViT- B/16). This system is able to classify interior room images into different kind of room genres and design-style, and consider users demand at the same time, including room size, budget, furnishing style, wall color, floor material, light preference, storage requirement and luxury level. Transferring learning, the system is capable of attainer a optimal classification accuracy with low training time and computational demand[30].

The personalized recommendation modules are used to provide fit-to-user requirements practical interior design suggestions, and the AI prompt generation module enables user to function the visualized simulation of customized room layout before implementation. Based on experiment results, illustrate our framework can reach accurate style identification, time-saving recommendation generation and high user satisfaction. Efficiently integrated intelligent image classification and personalized recommendation significantly reduce the interior layout designing work, and planning time and cost[28].

This development, as a general comprehensive, scalable system is so far the most convenient solution that could be provided for users in the décor field, ranging from home-owners, architects, interior designers, real estate agents..etc. It establishes a firm foundation to the future of smart interior design by integrating transfer learning, personalized recommendation and AI visualization altogether[29].

FUTURE WORK

To bring the proof of concept to a comprehensive intelligent interior planning tool, more work needs to be done on the proposed Personalized Interior Design Recommendation and Generation using Transfer Learning

framework. Part of the system can be further enhanced with leading edge Generative Artificial Intelligence models, like diffusion models or large scale text-2-image generation engines, which can generate photo-realistic and interactive visualizations of interior designs supporting multiple design options based on user context to offer more room for creativity.

In addition, later, more sophisticated works can be achieved by integrating 3D room modeling visualization, VR and AR visualization, so as to make users totally immersed into their customized room scheme and furniture arrangement for visualizing its impact, rather than only visualized on desktop monitor. Besides, recommendation system can be better optimized by user reinforcement reinforcement learning and preferences, so that the model can learn from the interaction with actual user.

Another potential improvement could be to utilize the Internet of Things and smart home idea to recommend intelligent lighting, smart home heating and cooling apparatus, environment friendly instruments based on the living condition and lifestylepractice of occupants. Realizing the prediction models in the cloud platform would help create scalable models and synchronous with users (E. Chen et al., 2016). Construction of a more complete feature vector on more types of rooms, interior decoration styles, and regional design traditions would improve the prediction model generality and the prediction classification accuracy. Multalanguage, voice controlled and environment-friendly in materials would build a smarter, interactive, scalable system and extend its application for various interior decoration needs in the world, for both house and office.

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