A Style Matching Approach for the Generative Design of Animated Posters

Danni Chang*, Yan Xiang*, and Xinyu Zhu

Abstract—Animated poster is a new form of visual expression that emerged in the new media era. Due to its vividness, narrative, and openness, it has a greater advantage in enhancing the audience experience and strengthening the message. The theoretical research on animated posters is being enriched and improved, while the research at the level of application practice is not sufficient. The existing tools are also difficult to meet the large number and diverse design needs. This paper therefore aims to complement the applied research, and further explore a parametric design method for such animated posters, in order to produce animated advertising materials with higher quality more easily. This paper explores the design factors of animated advertising posters based on literature review and an empirical study, and conducts in-depth research on stylized motion design and narrative structure. First, combined with Kansei Engineering and machine learning methods, the matching relationship between animation properties and style perception is explored based on Kansei Engineering and machine learning methods, in order to assist in choosing appropriate animations when designing posters. Secondly, the narrative structure and design methods that can be applied in this scene are summarized based on expert experience and case analysis. Then the heuristic rules of poster design are summarized, and the parameterized design model is proposed. Finally, based on this model and the conclusions of user research, a generation tool of animated advertising posters is designed and developed for small and medium-sized businesses and junior designers. In this platform, users can obtain animated posters with strong visual expression and communication efficiency by providing static materials and customizing styles. In the comparative experiment of poster evaluation, the results show that the animated advertising posters produced by the proposed model have a significant advantage in design diversity and quality compared to existing platforms. Moreover, the usability test shows that the generation tool can achieve better usability and effectiveness. Based on these results, the proposed tool is promising to contribute a more effective and productive generation process.

Index Terms—Animated posters, motion design, generative design, visualization, visual analytics

1 Introduction

In the context of the rapid development of mobile Internet technology and digital media, the medium and mode of information dissemination have undergone great changes, and the animated poster as a new form of design expression has become one of the most popular design trends at this stage, which has gradually received more attention in theory and application research [23, 44]. As an animated visual statement that changes its content over time, it breaks through the traditional visual paradigm of static posters, and is therefore more visually compelling and can present more information to the viewer [19]. With the richness and diversity of information reaching the public, people's aesthetic concepts are gradually improving [50], so they are more and more critical of media information, showing a tendency to pay attention to fast-paced, shallow reading and heavy experience. The animated posters with the advantages of visual expression and information communication are in line with the current public preference and demand [17].

Compared with the pioneering design practice of artistic expression, advertising and marketing is the most common and promising application scenario of animated posters [2]. Advertisers introduce animated design to traditional product posters in order to capture more users' attention and consumers' minds, to enhance the visual appeal and marketing communication effect of advertising posters and a beautiful and harmonious animated visual experience is the key to attract viewers and enhance the effectiveness of communication [7]. The design quality of animated advertising posters will affect the effectiveness of poster communication and viewers' perception results [14], therefore, it is worth exploring how to reasonably produce animated advertising posters with high quality at the design level to enhance the advertising effect [33].

This topic will start from the animated design elements of posters, carry out research on the design strategies and methods of animated advertising posters, and explore the design generation of posters based on this combined with relevant technical methods, so as to provide intelligent assistance for users to produce animated product posters with high quality.

2 Related Studies

2.1 Animated Poster Design and Application Research

Animated posters are a product of the new media era, and the research on this topic has shown exponential growth in recent years [44, 47]. The research trend shows that as the application of animated posters becomes more and more common, the topic has received extensive attention from both academia and industry [9, 10]. In terms of research content, the existing research mainly focuses on the development process, expression, application advantages and design guidelines of animated posters [5].

Animated poster is a kind of animated graphic design based on the traditional static print poster, and the traditional poster design has common design elements and design purposes, and follows the basic design principles [11, 25]. The advantages of animated posters compared with traditional static posters can be summarized as sensory experience and communication effectiveness. On the one hand, people's attention will be instinctively attracted by the animated effect, the animated support makes the poster break through the original picture effect, enhancing the vividness and interest [36]. On the other hand, the animated change of the poster can carry more information in a limited time [45]. However, some studies have shown that the animation of advertising can also cause negative emotions and negative impact on the audience [4, 24]. The reason for this is the design element of the poster. The misuse of ineffective animation can cause the poster to be "out of focus", which not only fails to take advantage of the animated poster, but also distracts the viewer's attention, hinders the message, and defeats the original purpose of the poster design [29]. At the design level,

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researchers have proposed different perspectives on the effectiveness of information transmission, image narrative, cognitive psychology, and so on, but the application of research in specific areas is not sufficient [34]. Animated posters can meet the communication needs of the current era, and their design quality is related to the communication effect and audience acceptance, so based on the existing research, the depth and expansion of the application level is a valuable direction.

2.2 Intelligent Design Methods for Advertising Posters

The development of intelligent technology has driven changes in many fields, and many problems in the design field are now being solved by introducing computer technology to seek new perspectives on the problem [46]. Research in intelligent design focuses on combining AI technologies to improve the efficiency and quality of design in steps such as graphic layout, screen color matching, and font selection [12]. Poster design methods incorporating intelligent technologies have now been richly researched and applied, and experience has been accumulated and deposited [21].

2.2.1 Kansei Engineering Approach

Kansei engineering is a multidisciplinary design method that integrates psychology, design, and statistics to study the correlation between people's emotional perception and design elements [39]. The research process based on Kansei engineering method is mainly divided into three stages: perceptual space construction, perceptual information acquisition, and association model construction [18].

In the stage of perceptual space construction, a semantic labeling system needs to be established by scientifically selecting the style intention vocabulary for evaluating the research object. In the perceptual information acquisition stage, it is necessary to collect the specific evaluations of the research subject sample under the perceptual space [41]. In the association model construction stage, the quantitative relationship between object characteristics and perceptual dimensions will be studied based on the collected perceptual information [22].

It can be seen that with the development of computer-aided technology, research methods such as natural language processing, neural networks, and genetic algorithms have also been applied to perceptual engineering research [27, 48], bringing new developments that help researchers better analyze and quantify people's perceptual cognition and provide design aids.

2.2.2 Generative Design Approach

Overall, the common generative design approaches in domestic and international research in the field of graphic design can be grouped into two categories: parametric approaches and deep learning approaches [1].

Parametric approach usually refers to the bottom-up parametric design concept based on heuristic rules or templates, which introduces rational algebraic thinking into design problems [30]. Deep learning method usually uses deep network models such as generative adversarial network (GAN) and graph neural network (GNN) [49]. The application of parametric methods requires sufficient a priori knowledge to define a series of heuristic rules or predefined templates with high controllability and interpretability for the generated results [28]. The application of deep learning methods does not need to pre-define a large number of rules, however, it requires a large number of training datasets, and its generated results are more diverse, but less controllable and interpretable [26].

In addition, through the combing of past research, the choice of technology for animated generation mainly includes programming languages such as Java, Javascript, and Actionscript. Some researchers used natural language processing techniques to analyze the content and context of classical poems, and used Flash Actionscript3.0 scripts to automatically generate poetry animations based on a library of collected animation materials [42]. While some developed animated engine based on HTML and CSS to generate text animations [38]. TextAlive [20] system is designed to generate text animations synchronized with music based on java language. Also, the motion constraints of design objects were written in the processing environment to generate and present interactive cluster animations [3]. The advantages of HTML5 cross-platform provide the technical basis for multi-channel delivery of advertising posters [40]. Therefore, the combined technology based on HTML, CSS and JavaScript to create and deliver animated advertising posters is a better technical choice nowadays.

3 Style Matching Methodology

Style semantics is a high-level, fuzzy and implicit feature, and different combinations of parameters of animated elements will evoke different subjective perceptions of viewers [15]. In order to realize a specific style of animated poster design, it is necessary to build a clear cognitive space of animated style semantics, quantitatively describe the association between explicit animated visual performance and implicit style semantic features, and lay the foundation for subsequent computer-aided generation design [35]. Based on the theory of perceptual engineering and related research methods, we establish an animated style-matching model based on the construction of animated style label system and animated element structure to realize the two-way matching of style and animated effect [31].

3.1 Semantic Keywords Identification

The semantic tagging of animation style aims to describe and explain the visual performance of animation by natural language, and establish a relatively consistent evaluation standard [43]. This study uses a funnel model to extract the key semantic features of animated style through three steps: extensive collection of semantic vocabulary, clustering and screening of semantic vocabulary, and validation of the evaluation system to build an animated style labeling system applicable to animated posters. This process will be described in detail in the following section.

3.1.1 Data Acquisition and Cleaning

In order to obtain the fullest semantic vocabulary possible to describe the advertising poster animated style, we extensively collected words that can be used to describe banner style, brand personality and visual performance of animated effects. In this stage, 446 English words were collected, and a preliminary corpus was constructed.

The collected words were then initially cleaned by word translation, word de-duplication, and word screening. Three experts with 3 to 5 years of design experience were invited to do preliminary screening of the cleaned semantic words to select words that are suitable for describing and describing the animated style, and that is clear and easy to understand. After cleaning and screening, 98 adjectives were left in the semantic lexicon.

3.1.2 Keywords Clustering and Filtering

After cleaning and filtering, the semantic lexicon still contains many words with similar meanings, which cannot be directly used for animated style evaluation, and the semantic lexicon needs to be clustered to extract representative words. The commonly used cluster analysis methods are K-means clustering and hierarchical clustering.

The KJ method of manual clustering was used in constructing the semantic lexical similarity matrix, also known as the affinity diagram or card sorting [13], was then used. The practice in this method requires participants to group semantically similar word cards together to obtain associations between words based on their sense of language. Studies have shown that there is a high correlation between the classification results obtained from a sample size of 15 and the classification results of all users, so that 15 subjects can obtain more reliable results in the card classification experiment. e invited 15 participants with 3-7 years of design experience to participate in an open-ended card-sorting experiment. In the experiment, each subject was asked to group 98 words according to their lexical similarity and describe the basis of their grouping in short sentences, without limiting the number of groups in the experiment

The obtained experimental data were imported into SPSS software for multidimensional scale analysis to obtain the Stress and RSQ indices of the data in different spatial dimensions (see Table 1). The Stress index reflects the fit of the model to the observed data, and the smaller the value, the better the fit of the model. RSQ, the coefficient of determination, indicates the proportion of the total variation that can be explained by the relative spatial distance, and the RSQ value close to 1 indicates a better fit. Based on experience, it is generally better to have RSQ value more than 0.6. Based on the results of the multidimensional scale analysis, the dimension is determined as six and the six-dimensional spatial coordinates of the data are derived.

Table 1: Results of multidimensional scale analysis.

Dimensionality	Stress Index	RSQ
2	0.61107	0.06192
3	0.39493	0.22438
4	0.22644	0.38728
5	0.18966	0.52473
6	0.16344	0.22438
7	0.22644	0.64482

The six-dimensional coordinates obtained in the previous step are clustered using the K-means algorithm, and the Calinski-Harabasz index (CH index) is used as a reference to evaluate the clustering effect, and a larger score of CH index indicates a better clustering effect, and its visual clustering results are shown in Figure 1. From the figure, we can see that when K=10, the CH index is the highest, indicating the best clustering effect. The thickness of each contour is similar at this time as seen from the contour map on the right, indicating that the clusters are of similar size. Therefore, the final use of the K-mean algorithm, based on the six-dimensional spatial coordinates after the multidimensional scale analysis, clustered the 98 perceptual words into 10 classes.

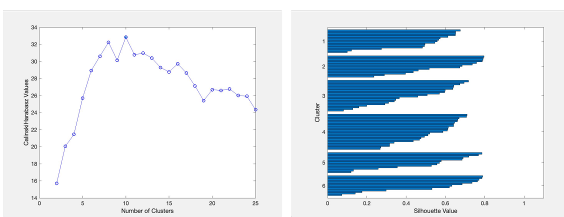

Fig. 1: Kmeans clustering results.

Due to the multi-sense nature of the vocabulary, positive and negative bipolar adjectives are usually used as evaluation dimensions in the semantic differential method. Paired perceptual words can convey semantic connotations more clearly than single words and facilitate perceptual evaluation. Therefore, based on the thesaurus clustering results, we conducted further lexical pairing. The K-means clustering method in the previous step allowed to obtain the central words of each of the 10 class clusters, which helped to select representative words for semantic pairing based on the animated dimension of each class description. In this stage, 9 semantic word pairs, i.e., 9 evaluation dimensions of the animated style, were finally obtained, as Table 2 is shown.

Table 2: Animated style evaluation dimensions.

Serial Number	Semantic word pairs	Description Dimension
1	Complex-Simple	Complexity
2	Popular - Futuristic	Novelty
3	Lively - Calm	Emotion
4	Intense - Relaxed	Strength
5	Exaggerated - Restrained	Exaggeration
6	Direct - Moderate	Speed
7	Smooth - Rhythmic	Smoothness
8	Lightweight - Steady	Weight
9	Spiritual - Mechanical	Weight

3.1.3 Semantic Optimization and Validation

The final step of the funnel model is to optimize and validate the initially constructed semantic evaluation space. Firstly, the semantic difference method needs to be used to obtain users' perceptual cognitive data about the research object, in which users are required to evaluate the samples in each dimension according to their subjective feelings when browsing the experimental samples. The data are then analyzed and processed with the help of mathematical and statistical methods, such as factor analysis and item analysis, to extract the most representative style evaluation dimensions. Previous studies have shown that at least 30 subjects are required in optimization validation experiments to obtain reliable evaluation data.

We collected 14 classic and commonly used animated effects from several well-known online design platforms and reproduced them using JS animations (see Figure 2). The samples were reproduced in GIF format as the experimental stimuli. The nine semantic dimensions of style obtained in the previous section were combined with a 7-point Likert scale to form a semantic differential scale for animated style evaluation. A total of 30 valid user data were obtained from the experiment, including 10 males and 20 females. Half of the subjects had no design or media-related background, reflecting to the greatest extent the common perception of the public on the semantics of animated emotion.

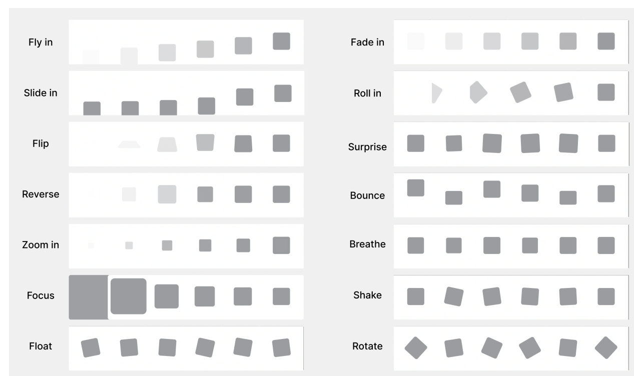

Fig. 2: Sample motion effects.

The validity and representativeness of the semantic word pairs were then verified by analyzing the experimental recall results. After comparing the methods, the critical ratio in item analysis was chosen to identify the contribution of each dimension, and Pearson correlation analysis was used to identify the correlation between the dimensions. The recovered scale data were imported into SPSS software for item analysis to obtain the cumulative total scores of each animated sample under nine dimensions, and this was ranked to obtain high and low groups. For example, in this study, 420 sets of data were summed and ranked (30 subjects rated 14 samples), and 27 percent of the total before and after, or 113 sets, were taken as the high and low groupings. Then independent sample t-tests were conducted on the two groups of samples to obtain the results of all dimensions under t-tests. Using a significance of 0.01 as the criterion, the significance of "complex-simple," "intense-relaxed," and "spiritual-mechanical" is greater than 0.01, indicating that these three pairs of terms do not differentiate in These three pairs of words were not significantly differentiated in the evaluation of animated style and were considered to be deleted. Subsequently, Pearson's correlation analysis of the remaining vocabulary dimensions revealed a significant correlation between "lively-calm" and "lightweight-steady" ($r=0.6$, $p<0.05$), so a group of word pairs was discarded.

After experimental validation, the remaining five most representative semantic word pairs constituted the evaluation system of animated style, namely, "direct-moderate" for describing speed, "lively-calm" for describing emotion, "popular-futuristic" for describing novelty, "smooth-rhythmic" for describing smoothness, and "exaggerated-restrained" for describing exaggeration.

3.2 Animation Effect Analysis

The content described by the style semantics is determined by the morphological elements of the described object, so the morphological elements are the key to the systematic perception of style as well as the style semantic features [32]. In order to better analyze the animated effect, it is required that the composition elements can describe and reflect the presentation effect of an animated effect to the greatest extent [51], and at the same time the elements themselves have relative independence and objectivity. Therefore, based on the above, we disassembled the basic components of animation effect into five aspects: motion subject, motion form, motion path, motion time and motion speed, which form the structure of animation elements.

Subsequently, matching associations of motion style semantics are established based on the structure of this motion element. We collected as comprehensive motion effects and speed curves as possible from several online design platforms, motion effect development libraries, and AfterEffects plug-in libraries, including sources such as Creatopy, Drafting Design, and Jingdong Antelope. Then we deduplicated them according to the basic elements of animated effects, and organized them into an animated effects library containing more than thirty kinds of effects. Figure 3 shows some of the animated effects in the library. At this stage, four basic units for further research on the semantics of animated style were finally determined based on the structure of animated elements: motion effect, motion duration, amplitude, and speed.

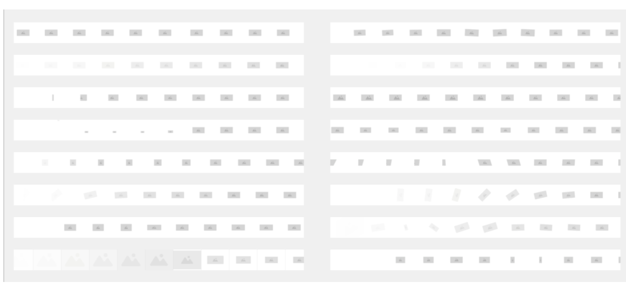

Fig. 3: Sample animations.

3.3 Joint Matching Approach Based on Back Propagation Neural Network and Genetic Algorithm

In the first two sections, the construction of the animated style labeling system and the analysis of the structure of animated elements were completed based on the Kansei engineering-related method, on which the matching association between the semantics of animated styles can be established. The relationship between animated design elements and viewers' style perception of their visual effects is not linear, and artificial neural networks (ANN) are good at building non-linear relationship models, so this method is often applied to solve such problems, for example, in the field of product design, most existing studies apply ANN models to predict users' intention perception based on styling elements [53]. Therefore, in this study, this method will also be used and combined with genetic algorithm to match the semantics of kinesthetic style [8].

3.3.1 Dataset Collection and Processing

The primary premise of the matching study is the creation of a matching dataset as material for network training. The kinesthetic samples in the dataset will be multivariate combined and created based on the kinesthetic element structure determined above. The dataset is annotated using a crowdsourcing method, and these kinesthetic samples are manually evaluated for style semantics using the semantic differential (SD) method [37] based on the kinesthetic style labeling system described above. In order to balance the number of model training sets and the cost of data annotation, the requirements are balanced by elemental downscaling and orthogonal experimental design. In the previous section, the four basic units of animated effects and their content elements have been determined, and some adjustments need to be made to them according to the requirements of the orthogonal test. We, with the help of 2 senior visual designers, determined the variable levels for the orthogonal test: i) 18 motion effects were screened from the animated library based on universality, variability and practicality, and the combination with two amplitude levels could include most of the effects of the animated library; ii)The range of values of suitable animated motion duration is determined from 250ms to 1700ms with reference to the cross-interaction effect specification, and it is equally divided into three levels of short, medium and long, and the respective median is selected as the representative value of the levels, where short is 250ms to 750ms, medium is 750ms to 1250ms and long is 1250ms to 1700ms; iii) Separate the slowing type and curve as two variable factors, and select five curves according to the variability and practicality, including Quad curve, Back curve, Quart curve, Elastic curve and Expo curve, which can make the variable level reduced while retaining more slowing curves.

After the creation of the animated samples, the semantic evaluation of the samples' styles was collected, i.e., the annotation of the training data set. The semantic evaluation of the animated effects was collected through an online questionnaire, and each participant had to watch the distributed animated samples in turn and evaluate them based on the 5 dimensions in the style labeling system using a 7-point Likert scale based semantic differential scale. Each kinesthetic sample needs to be evaluated by at least three subjects, and the final mean of the scores is counted to reduce the effect of individual differences on the semantic labeling of styles. The concept of vector is introduced on the annotation results to describe the style semantic evaluation of each kinesthetic sample. The vector of the ith kinesthetic sample in the semantic space is represented as Ei = W1 , W2 , W3 , W4 , W5 , i [1,324]. where W1 represents the composite score of the kinesthetic sample on the first dimension "crisp-calm", which takes values in the range [-3,3]. Since it was hoped that the semantic evaluation of style would reflect the perception of the general public, the background of the subjects was intentionally controlled in order to combine designers and the general public. The final number of subjects who participated in the style annotation was 18, of which 8 were male and 10 were female, and 10 of them were not design practitioners. After obtaining the semantic style scores of 324 animated samples from these 18 subjects, each score contained five dimensions, and taking the mean value of multiple scores for each animated sample, a final animated style evaluation dataset containing 324 items was constructed, with each item containing a set of animated attribute parameters and style evaluation scores under five dimensions.

In terms of data set pre-processing, since the feature values are not continuous but discrete and disordered of the animated elements, variable transformation of these qualitative discrete features is needed to facilitate the application to machine learning algorithms. In this study, one-hot coding is used to transform the variables. In terms of style semantics, each sample has a five-dimensional semantic vector with comprehensive multi-person evaluation. In order to make the model training easier to converge, the initial values are normalized so that each value in the vector is converted to the [0,1] interval.

3.3.2 Algorithm Modeling and Fitting

The focus of animated style prediction is to predict people's perceived style and its degree based on animated parameters, so a regression model is chosen for the algorithmic framework, and a back propagation (BP) neural network with strong nonlinear mapping capability is used to build the model in this study.

The input of the model in this paper is the animated attribute feature vector and the output is the animated style semantic vector. After several tests, the most suitable model structure for this dataset is finally determined, see Figure 4. The input layer has 30 nodes. The input layer has 30 nodes, corresponding to the animated attribute features, and the output layer has 5 nodes, corresponding to the 5 style dimensions of the style vector, including a hidden layer and a Dropout layer with 256 nodes and a dropout probability of 0.2. Since the model studies the regression problem, the mean square error MSE is chosen as the

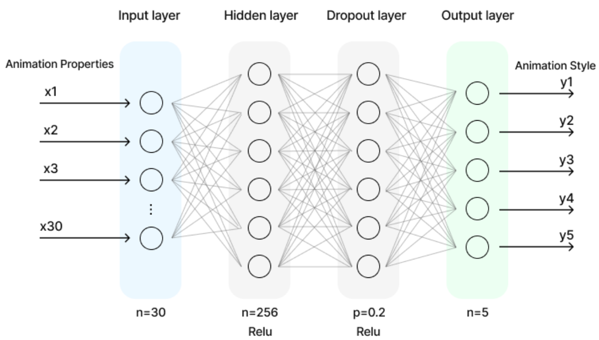

Fig. 4: Model structure of BPNN.

loss function, the optimizer is a stochastic gradient descent The Adam optimizer is used, and the activation function is the relu function. The learning rate of the model is set to 0.001 and the batchsize is 32. In order to avoid overfitting and improve the generalization ability of the model, the earlystop method is used in the training process to stop the model early when the performance no longer increases and the patience is set to 20. The data set was divided into a training set, a test set, and a validation set in the ratio of 6:2:2. The Keras tool library based on Python was used to build and fit the BP network model, and the loss curve of the training process is shown in Figure 5, which reflects that the model fits well without any obvious overfitting or underfitting. The final obtained neural network prediction model was tested several times, and the R-squared was stable in the interval of 73-76 percent, indicating that the model has good regression prediction quality. Three subjects involved in animated style labeling were also invited to apply the prediction model for instance validation, and their style prediction effects were evaluated to be within a reasonable range.

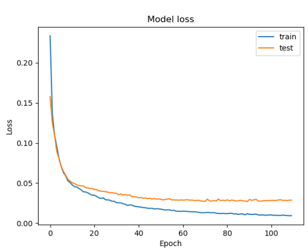

Fig. 5: Training and validation loss curves.

3.3.3 Animation Style Matching

In the previous section, a neural network model has been constructed to investigate the relationship between animated parameters and animated styles. However, in practical design application scenarios, designers or users often propose specific style intentions and hope to obtain matching design parameters as a reference for animated design [6]. Based on the already constructed semantic prediction model of animated style, this requirement is achievable. Theoretically, by enumerating the combinations of animated parameters and predicting their styles, the optimal combination of parameters reflecting the intended style can be found after repeated iterations. In order to achieve this goal quickly and effectively in practical application scenarios, a genetic algorithm is introduced in this study [52].

The genetic algorithm is a heuristic search algorithm often applied to optimization problems by iteratively modifying the population formed by individual solutions to evolve toward the optimal solution. In this paper, we also integrate the genetic algorithm with BP neural network based on its excellent global search ability, and use the BP network as the fitness function of the genetic algorithm to obtain the animated combination that meets the user's style intention in a more efficient way. Figure 6 shows the framework of genetic algorithm used in this paper.

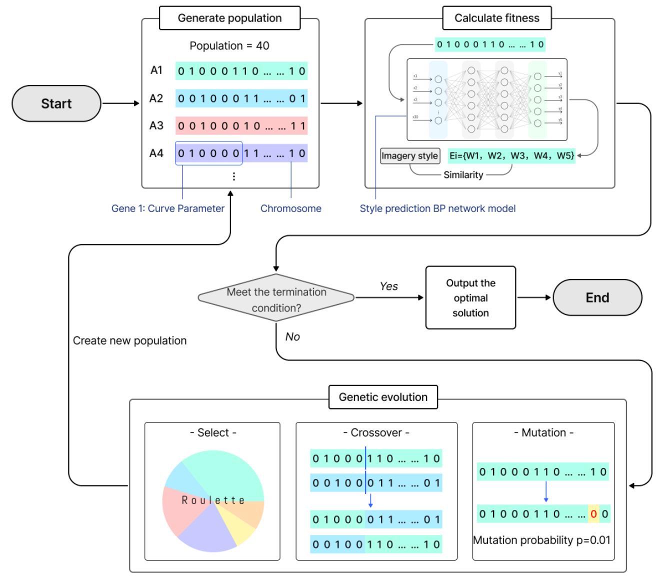

Fig. 6: Genetic algorithm framework of the style-matching model.

The application of genetic algorithm needs to complete the definition of genetic encoding method and fitness function first. Genetic coding is the process of encoding a solution into chromosomes, and in this study the solution refers to a combination of several animated design parameters. Binary coding is the most commonly used coding method in genetic algorithms, and the results of coding in this way are exactly the same as the coding results of the neural network dataset constructed in the previous section, and can be directly used. The fitness function is then defined. Since the goal is to find the animated combination that best reflects the intentional style, the fitness function is set as the similarity between the style of the solution and the intentional style, and the optimal solution with the highest similarity is found in continuous genetic iterations. The genetic evolution operation includes selection, crossover and variation operators. The selection process uses the common roulette wheel selection method, i.e. individuals with higher fitness scores have a higher probability of being selected and passing on their genotypes to their offspring, but individuals with low fitness also have a certain probability of being selected. During crossover some of the chromosomes of an individual are crossed over and recombined, thus creating new chromosomes. The mutation process in which several chromosome values of individuals mutate randomly to create new individuals, the purpose of mutation is to randomly update the population and introduce new patterns to existing populations. In the genetic algorithm, the population size is set to 40, the mutation probability is 0.01, and other parameters are selected as default values. When the best fitness value is not updated for 5 consecutive generations or the number of iterations of the algorithm reaches the maximum number of generations 30, the algorithm will be stopped and the best value at this time will be output. This completes the structure construction of the style-matching model.

For the implementation of the matching model, the main framework of genetic algorithm was built in Python environment based on Scikit-opt library, and the trained style prediction BP network model was applied. Subsequently, the effect of the style-matching model was verified by inviting three experts with experience in motion design to use the model and evaluate its matching effect. The experts formulated 5 sets of style intentions and input them into the model, previewed the output animated effects, and then evaluated their satisfaction with the effect on a 5-point Likert scale (1 very dissatisfied, 2 very dissatisfied, 3 average, 4 very satisfied, 5 very satisfied). the mean satisfaction value of the 5 animated effects was considered as the experts' evaluation of the effect of the matching model. The average rating of the three experts on the effectiveness of the matching model is 4.03, indicating that the model is basically able to match the user's needs with the appropriate style of animation as a design reference.

4 The Generative Design Platform

We conducted an animated generation design study based on existing structured posters and identified the main technical route of parametric generation and presentation with HTML and JS animation frameworks.

4.1 Generative Method

The generation path of animated advertising poster refers to the designer's poster design process, in order to obtain the material, content understanding, parameter generation and adjustment, decoding display four major steps, as shown in Figure 7.

The first step is to obtain the content material and design goals for the generated design. In this generation model, the poster in PSD format, the native file format of Photoshop, is used as the content material, preserving the structured layering information in the poster design. The design goal is the style that the user wants the animated poster to reveal when it is presented, in the form of a style vector containing 5 dimensions entered into the model.

In the content understanding phase, the system needs to convert the input content material into its own programming language. Specifically, the necessary parameters such as layer name, layer type, layer content, layer order, layer coordinates, layer size, effect mode, etc. of the poster need to be obtained from the PSD file and stored as objects in a structured manner. The JS library psd.js is called here to parse and read the PSD file, which is a generic PSD parser built on PSD.rb to process Photoshop files in the browser using a manageable tree structure to obtain key layer information within the file. At this stage it is also necessary to complete content annotation of layer elements for subsequent generation. Text layers and background layers can be identified by layer type, order and size. The identification of the title and body layers requires manual annotation by the user or by calling the image recognition API.

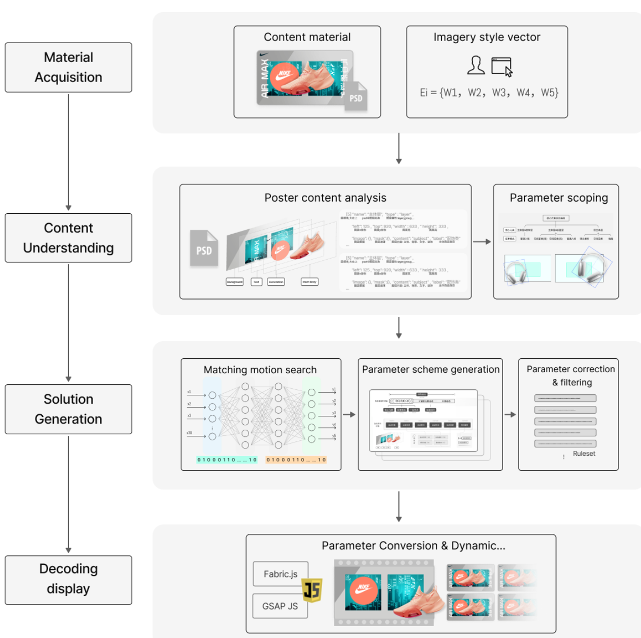

Fig. 7: Generation process of animated posters Generation process of animated posters.

After getting the poster property parameters through file parsing, you can set the value range for some of the parameters of the animated poster, and adjust the frame parameter range according to the element layer composition. Under the two narrative modes of "camera roll" and "spatial transformation", the four numerical parameters of horizontal coordinates, vertical coordinates, rotation value and scaling value at the end state of "a section of movement" need to be randomly generated by the system. In order to ensure that the subject is within the recognizable area of the screen and has a certain visual aesthetic, the position generation function is encapsulated to set the position coordinates within a safe range according to the size of the poster canvas and the size of the subject layer (see Figure 8), and the rotation and scaling parameters are constrained.

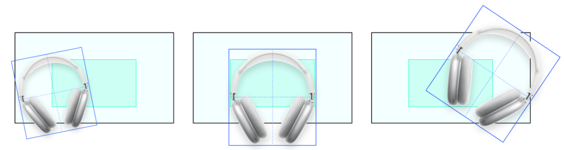

Fig. 8: Animation options of background layer.

In the parameter generation and adjustment phase, the system will perform the matching search of animated effects and the generation of animated solutions. Firstly, in the process of matching animated effects, the animated style-matching model constructed in Chapter 3 will be invoked. The model uses genetic algorithm as the framework and BP neural network model as the fitness function to search the combination of animated parameters with the highest similarity to the input imagery style in parallel and efficiently in continuous genetic evolution. The animated parameters obtained by matching search of this model will be used as the main style parameters of the poster and determine the style tone of the overall animated poster. Then the animated scheme is generated, based on the scheme parameter structure constructed in the previous section, following the order of frame first and then animated effect, 5 frame parameters and several sets of animated effect parameters are randomly generated within the respective parameter range according to the poster properties and generation mechanism to form an animated scheme, a total of 15 schemes are generated in one batch. In order to control the quality of the generated solutions, the initial generation mechanism is supplemented with some design rules, which were added to the initial generation mechanism, which were obtained by inviting many design experts to try and evaluate the initial model after we finished it, and summarized in the discussion. The rules are related to the recognizability of the text layer, the consistency of the overall animated style of the poster and the richness of the animated effects.

The presentation of animated solutions requires a specific environment. So we use HTML and JS animations to display animated posters on the web side, so the parameters need to be parsed and converted. Specifically, the animation framework is built based on GSAP.js, which encapsulates some necessary forms of animated effects and leaves space for parameter adjustment, and the parameters of the animated scheme are transformed into animation description statements under this framework to present animated effects in the browser for users to preview and select. So far, the complete generation path of design material acquisition, poster content analysis, animated scheme parameterization generation and filtering, and animated poster presentation is completed.

4.2 Design Platform Development

4.2.1 System Functional Architecture

For the core requirements of in the user operation flow distilled in the previous interview, the corresponding functional solutions are set. The main patterns include design-based generation, and product diagram-based generation. Based on typical usage scenarios and technical implementation considerations, the web application is chosen as the vehicle for the generation tool.

4.2.2 System Interaction Flow

Based on the system functional architecture, combined with the light and convenient product positioning, further planning the interaction flow of the tool (see Figure 9). In the design-based generation mode, the user first uploads the PSD source file of the design, the system reads and parses the poster information in the background, and then displays the preview screen after finishing reading. After the user input the intended animated style, the system will match the style animated effect and animated poster generation in the background. After the load is completed to show the user a batch of animated solutions, the user can preview, comparison, selection of solutions in turn, for a specific program users can select the format to download and export, save the program into favorites or enter the edit mode to further adjust the animation duration, path and other parameters. If the batch of all the programs are not satisfied, the user can click the replace button to get a new batch of programs, or return to the style definition page to fine-tune the intended style parameters to generate again, until the satisfaction of the animated poster.

In the product diagram-based generation mode, firstly, users upload the main product image that needs to make posters, and then the system successfully reads the image information and displays the preview screen and template list, and locates the recommended tabs of similar categories. Users can filter the templates according to the category, intention style and size and other tags. After selecting a template, the system automatically replaces the main body and adjusts the image size and position, and modifies the template color scheme according to the main body information. Users can customize the static content, such as copy, object size and position, and color scheme according to their personalized needs, or enter edit mode to adjust the animated effect until they get a satisfactory result and export to download. Projects can be saved to personal center to support subsequent changes.

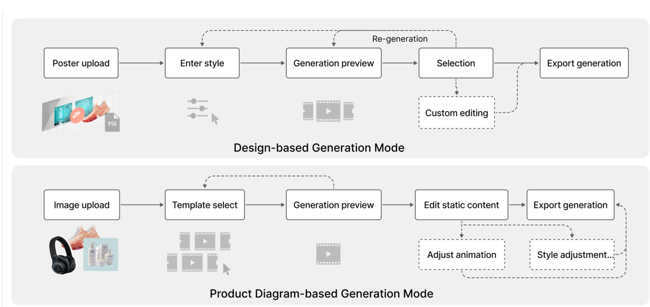

Fig. 9: Interaction process of the design system.

4.2.3 Interface Design

After the process of combing, the core user pages in the system interaction link include the home page, personal center page, material upload page, style selection page, generation loading page, solution preview page, and free editing page, of which the last three pages were adjusted accordingly in the two generation modes. Since the target users of the tool include designers and general merchants without design background, the interface needs to be simple, clear and easy to understand, so the design strategy of the system is determined (see Table 3).

Table 3: User interface design strategy.

Scope	Design Strategy
Information Architecture	The overall structure is wide and shallow, with additional layers in places
Color	Dark mode color scheme for visual noise reduction
Controls	Text-based buttons with clear functional intent
Copywriting	Popularized expression, clear guidance

In the interface design, attention was paid to functional guidance and explanation, and the information on the same page was kept concise by appropriately increasing the functional hierarchy to ensure the simplicity and fluency of the main flow. As the animated poster itself is visually rich, the visual design of the tool adopts a dark color pattern so as to reduce noise and enhance immersion for visuals, while the important parts are highlighted in cyan. The prototype interface is designed based on the design specifications of web applications.

It mainly contains: home page, personal center page, material upload page, style selection page, generation loading page, solution preview page and free editing page, etc. The following example briefly shows some of these pages, see Figure 10.

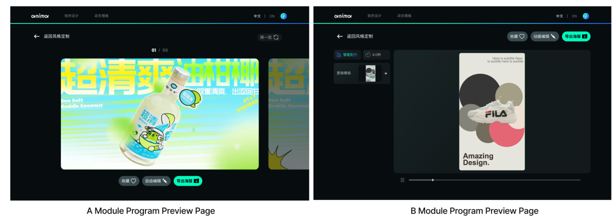

Fig. 10: Design preview page.

4.2.4 Prototype Construction

In the prototype building phase, a high-fidelity prototype of the poster generation tool web application was first created through the Figma platform to realize and refine more conceptual ideas. The functional prototype was then developed based on the H5 web framework to validate and implement the core functions in the conceptual design, i.e., the generation process of the two models. The functional prototype was divided into two parts, web front-end and server back-end, as shown in Figure 11. The front-end logic is mainly written based on JavaScript's JQuery, which mainly contains three parts, one of which is to show the user operation GUI interface, supporting users to upload files and point-and-click interactions in the browser; the other is to perform preliminary data processing and API calls, such as calling Psd.js to parse files in module A, and calling the Colorthief API to parse images in module B. Colorthief API is called in module B to parse image color matching. Finally, the animated scheme parameters are received and parsed from the backend, and the animated scheme is rendered in the browser based on GSAP.js. The back-end logic is written in Python, and the back-end mainly accepts front-end commands for animated style-matching, animated scheme parameter generation, and animated template data access.

Stable communication between web-side and server-side is a prerequisite for the implementation of the prototype. In this paper, we implement WebSocket, a communication protocol provided by HTML5, to communicate with the server (Python) and transfer data and information between the server and the client. To implement the communication between the two, you need to create a WebSocket object and set the same port on both the web side and the server side.

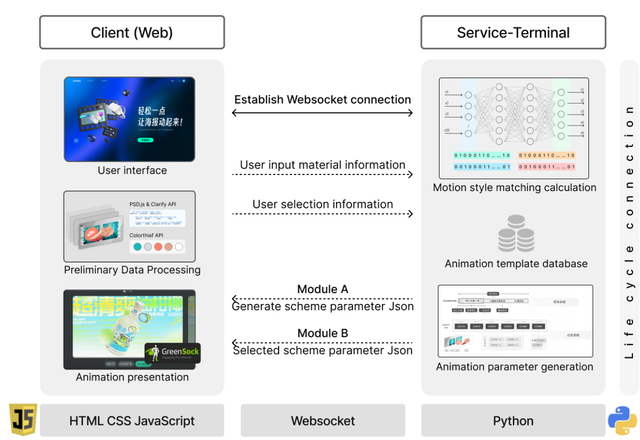

Fig. 11: System structure of the prototype.

5 Testing and Evaluation

The matching model between animated attributes and style semantics is obtained through the construction of the preamble, the narrative and design techniques applicable to advertising posters are summarized, and a parametric generation model for animated advertising posters is proposed on this basis. In this subsection, the effectiveness of this generative model will be evaluated through experiments.

5.1 Poster Generation Effect Test Evaluation

5.1.1 Evaluation Criteria

The diversity of the generated animated posters was one of the evaluation criteria. The criteria for this evaluation were thus determined to include the three dimensions of i) poster quality, ii) advertising effectiveness, and iii) generation diversity.

5.1.2 Experimental Stimuli

Twelve static poster materials were selected for the experiment, and animated solutions or input parameters were selected to generate and export an animated solution based on the same stylistic intention in both platforms, and the final experimental stimuli contained 24 animated solutions.

5.1.3 Experimental Process

The experimental process includes two parts: memory test and subjective evaluation. In the memory test part, the posters generated by the model of this study were used as the material for the experimental group and the posters generated by the design platform were used as the material for the control group. The subjects were divided into two groups in the experiment and watched 12 animated posters of the experimental group or the control group respectively, and took a break to eliminate the subjects' short-term memory, and after the break time, the subjects were required to search for the previously viewed 12 animated posters with subject-level elements. Eighteen of the product images served as interference, and products of different brands in the same category that were more similar to the main body of the original poster were selected. The final statistics of the accuracy of product image selection. In the subjective assessment part, all animated posters were divided into three groups based on stylistic similarity, the experimental group and the control group material included a total of six groups. In the experiment, each subject was asked to view all six animated posters in their entirety, and the order of presentation was randomized between the experimental and control groups. After viewing each set of posters, subjects were asked to fill out a subjective engagement and diversity assessment scale, based on a 5-point Likert scale.

5.1.4 Analysis of Experimental Results

A total of 24 subjects aged 20-30 years old participated in the memory test and subjective assessment experiment, 16 of them were female and 8 were male, 10 of them had no media, advertising and design-related background.

(1) Memory test: the recall of the advertisement is the percent of people who correctly recalled the main product in the poster, and the recall of each poster in the experimental group and the control group was calculated as shown in Figure 4-17. A t-test (see Table 4) was used for both groups, $t = 2.281$, $r = .043 < 0.05$, indicating that there was a significant difference between the two groups and that the experimental group had a higher memory effect than the control group. The results indicate that the animated posters generated by the model of this study have better ad memory effect compared to the posters generated by the existing platform.

Table 4: Paired t-test for memory test.

	Standard deviation	t-value	Significance (two-tailed)
Experimental group-control group	0.1793	2.281	0.043

(2) Subjective assessment: the reliability test was conducted on the scale data recovered from the questionnaire, and the Cronbach alpha coefficient was 0.835, indicating that the reliability was high enough for subsequent analysis. The quality of the generated posters was assessed using a user engagement scale, and the overall engagement score was calculated from the scores of the three dimensions. The 12 posters of the experimental group were divided into 3 groups for scoring, and the scores of the 3 groups were summed up as the total score of the experimental group, and the control group was statistically sampled in the same way. A paired t-test was used to compare the scores of the three groups of posters and the total score of the control group, and the results are shown in Tables 5.

Table 5: Quality assessment paired t-test of experimental group-control group.

	Mean value	Standard deviation	t-value	Significance
Total Score	3.95833	6.70807	2.891	0.008
Group 1	1.16667	1.71100	3.340	0.003
Group 2	0.58333	3.22917	0.885	0.385
Group 3	2.20833	3.40050	3.181	0.004

(3) Generating diversity assessment: the data analysis method for generating diversity of results is the same as the quality assessment. The results of the data analysis are shown in Table 6. The posters of the experimental group are significantly higher than the control group in terms of group and total scores, which indicates that the animated poster generation model proposed in this paper has a certain diversity of generation results under similar intentional styles.

Table 6: Diversity assessment paired t-test of experimental group-control group.

	Mean value	Standard deviation	t-value	Significance
Total Score	7.58333	5.97034	6.223	0.000
Group 1	1.95833	2.36789	4.052	0.000
Group 2	2.41667	2.35753	5.022	0.000
Group 3	3.20833	2.34018	6.716	0.000

(4) Experimental conclusion: the results of the two experiments, memory test and subjective quality and diversity assessment, reflect that the animated poster generation model based on style-semantic matching and narrative planning proposed in this paper can produce animated advertising posters with richer perception and more marketing effect, and better convey the poster message to the audience. It also reflects that the form of animated posters has its own advantageous areas, and not all posters need to add animations intentionally to enhance the visual effect.

5.2 Usability Test of the System

Based on the functional design and interaction process of the generation tool, we evaluate the system usability of the generation tool through the completion of usability testing tasks, subjective scales and feedback from subjects, extract usability problems encountered by users in the process of use, and guide the direction of system design optimization iteration, so as to obtain a better user experience.

5.2.1 Experimental Design and Procedure

The complete experimental flow is shown in Figure 5-12, including four processes: product introduction, prototype experience, scale evaluation, and post-test interview.

Firstly, the main subject briefed the user on the background of the experiment and the system functionality. Then the subject completes the experience of generating two modules of the system according to the provided task list. During the task test, the subject observed and recorded the task completion time and completion status. Subjects were required to fill out a subjective scale after completing the test tasks. Since the main design goal of this poster generation tool is to be simple and easy to use, the widely used usability scale (SUS) was used to evaluate whether the design is easy for users to understand and use. At the end of the test, the subject was asked about his or her feelings during the test, and additional questions were asked about the problems recorded during the task to collect suggestions for the product module functionality and interface design. The list of tasks in the task test included the core interaction flow of the two poster generation modules, including design-based generation mode, and product diagram-based generation mode. Each experiment lasted approximately 15 minutes.

In usability testing, six to eight users were able to identify more than 80 percent of the system usability problems in the product.[67] In the usability test, six to eight users were able to find more than 80 percent of the system usability problems. A total of nine subjects were recruited for this usability experiment, including three male and six female subjects, five of whom had design backgrounds.

5.2.2 Analysis of Experimental Results

The subjective scale data and task completion obtained during the experiment were statistically analyzed by Excel and SPSS software, and the user feedback during the experiment was sorted according to the module pages.The scale data were analyzed, and the Cronbach alpha coefficient of 0.876 indicated that the reliability of the recovered data was high enough for subsequent analysis. The final system SUS scores are shown in Table 7 The total score is 82.78, and the usability of the animated advertising poster generation system proposed in this paper can be known to be high by the criteria proposed by Bangor et al.

Table 7: SUS scale score statistics.

Overall(100)	Learnability(30)	Efficiency and usability (40)	Satisfaction(30)
82.78	24.44	30.83	25.83

At the same time, user feedback also revealed that the proposed system has the following four problems in the interaction of the solution preview page (1) inefficient solution selection (2) ambiguous button function (3) lack of withdrawal mechanism (4) unclear editing function. Finally, we proposed solutions to these four problems and completed the design iteration of the relevant interface. The interface design of the solution preview page in both modules was further iterated based on the proposed solutions.

6 Conclusion and Discussion

In this paper, the research on animated advertising poster design is conducted to address the practical problems of high demand for animated posters in advertising and marketing scenarios, but the production threshold is high and the design quality varies. In this study, we investigate the design influencing factors of animated advertising posters through literature research and empirical study, focus on stylized animated effects and poster narrative arrangement, construct a semantic matching model of animated style, summarize the poster design strategy, and build a parametric generation model of animated advertising posters. In the design practice, a prototype of animated advertising poster generation tool targeting small and medium-sized businesses and junior designers is designed and developed based on the design thinking approach, and the validity and system usability of the model is verified by testing.

The main contributions of this paper are as follows:

Firstly, under the guidance of the perceptual engineering research framework, a five-dimensional model for animated style evaluation is obtained and a style labeling system for animated effects is constructed based on the funnel model through semantic vocabulary collection and cleaning, vocabulary clustering and screening, and vocabulary optimization and verification. The structure of dynamic elements was established by disassembling basic element attributes, collecting and filtering common dynamic effects. Through the generation of dynamic samples and style labeling collection, a dynamic style labeling dataset was established. Based on this dataset, a BP neural network model for animated style prediction was trained, and an animated style-matching model was built by combining genetic algorithm to achieve two-way matching of animated effects and style semantics to solve the problem of animated effect selection during poster design.

Secondly, the parametric generation model of animated advertising posters is proposed by integrating the dynamic style-matching model, planning the technical route and completing the prototype implementation. In the comparison experiment of model effect evaluation, the validity of the generated model was verified by subjective quality evaluation and memory test, and the diversity of model generation was verified by subjective diversity evaluation.

Thirdly, design practice and user evaluation were carried out based on the design thinking approach. The user pain points and needs were investigated, the system architecture of the design tool was clarified and a feasible technical route was constructed, the design performance was refined based on the design strategy, and the web application prototype design of the generation tool was completed. The usability of the prototype system was evaluated by usability testing and system usability scale, and a design iteration was completed based on user feedback.

Admittedly, there are certain limitations in this paper, and the outlook for subsequent research is dynamic dataset extension and optimization. In this study, the quantitative relationship between dynamic style semantics and dynamic attributes is explored, and a style-matching model is established. However, due to the time and cost required to generate and collect the kinesthetic samples, this study was limited by the time to train the network model with a small dataset and coarse granularity in coding the kinesthetic attributes. In order to obtain a better matching model, the size of the dataset can be appropriately expanded in subsequent studies. In addition, there is a very wide space for dynamic design, and the application of dynamic design is constantly developing, and more and more animation expressions will be available in the future, so the subsequent research can also do more fine-grained analysis and modeling of dynamic attributes to explore more generalized dynamic matching methods.

In conclusion, the animated poster generation method and tool proposed in this paper achieves the innovation of method application, which can be used as a functional supplement to the existing online design platform to help merchants and designers to create animated advertisements with high quality easily and quickly, and has certain application value and research value. At the same time, based on the previous theoretical research, this paper takes the style semantics of animated effects as the focus of animated poster design, composes and summarizes the animated style-matching and poster narrative design methods and explores them in depth, which complements and enriches the application research of animated posters and provides reference methods and ideas for subsequent research [16], with certain theoretical innovation and research significance.

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