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AI-Driven Interactive Painting Synthesis System for Children's Art Education

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Abstract. Art education is important to the overall development of children, and art training can start from improving children's art appreciation and perception. In this study, we built an interactive painting synthesis system for children's art education to let them know about world famous paintings and art history. The interactive learning systems can provide engaging ways of art education based on image synthesis, style transfer and animation generation technology. Specifically, an image dataset of famous paintings was established for painting synthesis and an application "ARTIST" was developed based on First Order Motion Method. The system "ARTIST" can attract children's active participation via interesting art creation interaction and enhance their learning motivation in their exploration.

Keywords. Art education, Painting synthesis, First order motion

1. Introduction

Art education helps children develop their language, social communication, decision-making, risk-taking, and invention skills. The artificial intelligence industry is booming over recent years, and the field of children's art education is undergoing tremendous change. The continuous development of digital technology provides children with varied learning experiences. Through interactive learning, children can be deeply involved in the learning process, which increases their interest of learning. Artistic learning, as a creative form of education, is also gradually emerging in the trend of digital children's education [1]. Digital media and applications enable children to appreciate and learn about works of art in a virtual environment, thus developing their aesthetic cognitive ability [2].

In this work, we applied image synthesis and animation generation techniques to develop a learning system "ARTIST" which guided children to learn about art appreciation and art history. Specifically, the system allows users to interact by clicking on image segments in the painting to explore detailed information about the artwork with an immersive experience. Additionally, the system ensures introduction of new and engaging activities, attracting children's active participation and enhancing their learning motivation. Besides, the system facilitates comprehensive online art

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history education, enriching children's knowledge. The research roadmap of this work is presented in Figure 1.

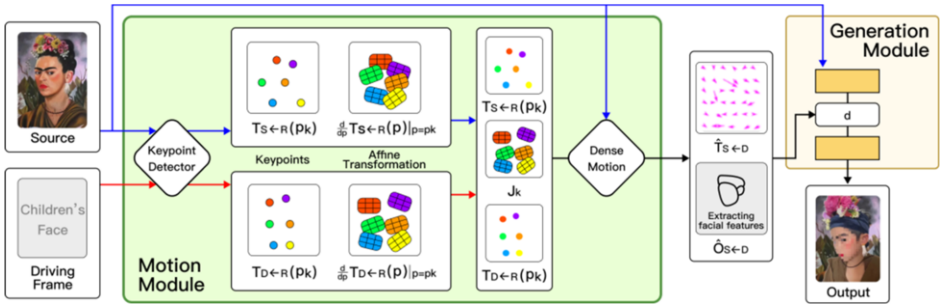

Figure 1. Research roadmap of painting synthesis exploration for children's art education.

The main contribution of this work can be concluded in two aspects: (1) A dataset of famous paintings with image segmentation was established; (2) An "ARTIST" application for children's art education was developed based on First Order Motion Method.

2. Related Work

2.1. Research and development of digital art exploration applications

Over the past few years, a number of interactive learning systems have emerged that aimed to provide more engaging ways of learning through AI technology [3]. For example, virtual museum applications can lead children to explore history and culture, and digital drawing tools can help children to create their own works of art [4]. In addition, some digital art applications were developed based on image generation and style transfer techniques that enabled users to blend their own photographs with famous paintings to create personalized art works [5].

2.2. Image synthesis and animation generation techniques

Various techniques can provide support on art style transfer and animation generation, including convolutional network, Generative Adversarial Network and Transformer model etc. [6].

First Order Motion has been widely utilized for dynamic generation and transformation of images and videos. This model, based on deep learning technology, can apply the motion and style of a source image or video to a target image or video, thereby achieving style transfer and animation generation [7]. In the existing research, this model is extensively employed in various domains, such as video animation generation, expression transformation, and artistic creation. It has remarkable capabilities of creating vivid effect in multimedia generation and transformation [8].

FFmpeg provides powerful support for digital art and animation as a multimedia processing tool. It can be used for tasks such as video compositing, format conversion and animation rendering. In our study, we applied FFmpeg to combine the generated

animation effects with images of famous paintings to create smooth and vivid interactive scenes.

3. Methodology

In this study, we aimed to realize the interactive learning way for art education. We set up interactive learning module, art exploration game in art and animation generation function. A dataset of famous art paintings were built for the experiment. And First Order Motion method was applied for image feature detection and feature matching in artwork recreation process.

3.1. Datasets

We collected images of world famous paintings from various artists in different periods. These data were filtered, standardized and converted into a standardized .jpg format for processing by the system[9]. We acquired images of famous paintings from public art databases, museum websites and online art communities. Then we conducted image preprocessing, including noise reduction, contrast enhancement and color correction to ensure image quality and consistency [10]. The dataset is presented as a gallery in the system, in which users can browse through various famous paintings. The information of the artworks is shown in the labeling, including the artist, art period, and style.

3.2. Image segmentation

In the painting exploration function, users have the opportunity to engage with the detailed information of the painting segments, facilitating exploration of distinct sections. Thus, image segmentation was performed on the paintings to extract specific regions [11][12]. The applied method is shown as follows.

Algorithm 1 : Image Segmentation and Detail Extraction

(1) ***Initialization :*** *import cv2 ,import numpy as np*

(2)
```
def image_segmentation(image):
    # Perform image segmentation using OpenCV to extract
  detail regions
    # Return the segmented detail image pass

     # Read the painting image
    painting_image = cv2.imread('painting.jpg')

    # Perform image segmentation and detail
    extraction detail_image =
   image_segmentation(painting_image)
```

(3) ***Output:*** *cv2.imshow('Detail Image', detail_image),cv2.waitKey(0) ,cv2.destroyAllWindows()*

3.3. First Order Motion

To achieve the animation of famous paintings, the initial step involves faces detection in artworks. Subsequently, First Order Motion was employed to extract pre-recorded reference videos from the database [10][11]. Then, audio and video elements were integrated by FFmpeg.

In model training process, we used a diverse video dataset of the same object category. Our model learns to reconstruct training videos by merging a single frame with a learned motion latent representation [12]. It captures motion via keypoint shifts and local affine transformations in frame pairs from the same video. During model testing, our model applied learned motion to pairs of source image and created video frames.

This sequential program brought the characters depicted in the artwork to life and dynamically introduced themselves. The applied method is presented as follows.

Algorithm 2 : Paintings Motion Generation

(1) ***Initialization :*** *import cv2,import imageio,from skimage.transform import resize,from demo import load_checkpoints, make_animation*

(2)
```
# Load pre-trained model
generator, kp_detector =
load_checkpoints(config_path='config/vox-256.yaml',
                 checkpoint_path='vox-cpk.pth.tar')

# Read the painting detail image
painting_detail = cv2.imread('painting_detail.jpg')

# Prepare user photo (can be your own photo)
user_photo = cv2.imread('user_photo.jpg')
user_photo = resize(user_photo, (256, 256))[..., :3]

# Generate animation using the First Order Motion model
predictions = make_animation(user_photo, painting_detail,
generator, kp_detector, relative=True)
```

(3) ***Output:*** *for frame in predictions: cv2.imshow('Animated Painting', frame)*
if cv2.waitKey(25) & 0xFF == ord('q'):
break,cv2.destroyAllWindows()

3.4. "Picturesque" interactive experience

We hope to create an immersive "picturesque" artistic experience for children, making them feel like being in the scene of the artwork To implement the "Picturesque" experience, we blended painting features with users' portrait characters. The method is illustrated as follows [13].

Algorithm 3 : Picturesque

(1) ***Initialization :*** *import imageio,from skimage.transform import resize,from demo import load_checkpoints, make_animation*

(2)
```
# Load pre-trained model
generator, kp_detector =
load_checkpoints(config_path='config/vox-256.yaml',
                 checkpoint_path='vox-cpk.pth.tar')
# Read the painting detail image and user photo
painting_detail = cv2.imread('detail_image.jpg') user_photo
= cv2.imread('user_photo.jpg')
# Resize user photo to match the painting detail
user_photo = resize(user_photo, (256, 256))[..., :3]
# Embed user photo using the First Order Motion model
predictions = make_animation(user_photo, painting_detail,
generator, kp_detector, relative=True)
```

(3) ***Output:*** *imageio.mimsave('embedded_animation.gif', [img_as_ubyte(frame) for frame in predictions])*

4. Application

An art learning system "ARTIST" was developed based on the proposed method. It can guide children to learn about famous paintings through interactive games [14]. Users can access our "ARTIST" learning system through their mobile devices, and learn knowledge by clicking on the segments in the paintings to get dynamic interactive feedback. The system architecture and module design are shown in Figure 2.

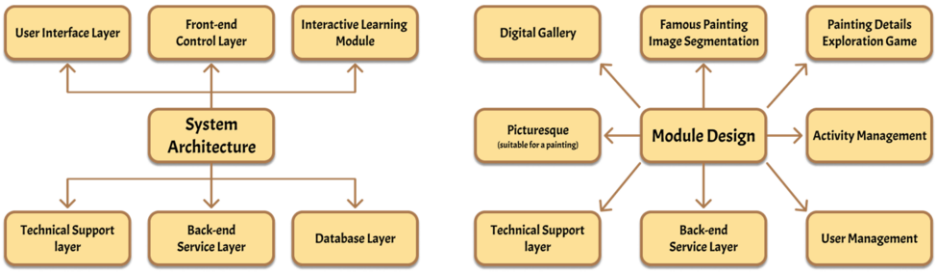

Figure 2. System architecture and module design.

4.1. Application modules

The main application modules of this system can be concluded in three aspects:

- The Interactive Learning Module is devised to enhance children's comprehension and learning of renowned artworks. The Interactive Learning mode of "Famous Paintings in Motion" predominantly enables individuals or objects within famous paintings to introduce themselves via the First Order Motion model, imparting the knowledge of famous paintings to children through a distinctive interactive approach.

- The Detail Exploration Game constitutes an inventive exploration module founded on image segmentation technology: participants are asked to uncover concealed intricacies within paintings, including objects and expressions of secondary characters, which can train children's ability of observation and analysis [15][16].
- The "Picturesque" function empowers users to integrate their personal photos into renowned artworks, fostering captivating interactive scenes. Users can select different paintings, and observe subsequent interactions with the characters in the artwork. This personalized interactive experience helps stimulate children's creativity and imagination [17].

4.2. User interface demonstration

The specific usage process of the system is as follows:

- Firstly, the homepage displays the introduction of online activities and present famous painting gallery of the day for users to enjoy and learn, see Figure 3.

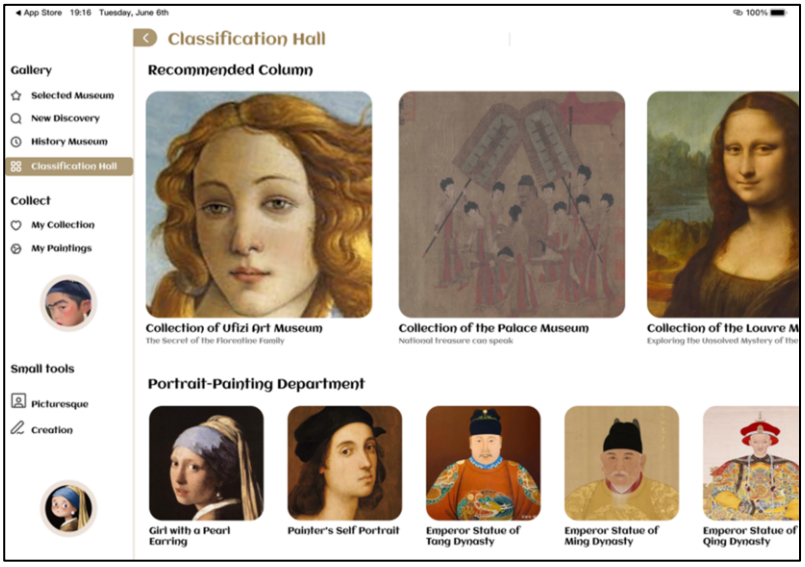

Figure 3. Homepage interface of the system.

- Secondly, users can also click on the resource library to view famous artistic paintings, with a detailed list of the artwork name, art period, artist's name, and exhibition museum of the paintings etc.
- Thirdly, each painting is set with interactive learning panels for further exploration. Specifically, story panels can provide introduction of the artwork, see Figure 4. And exploration panel presents interactive learning of the details of the paintings and artistic style transfer effect of user portrait image, see Figure 5.

Figure 4. Interactive learning module of the system.

Figure 5. The artistic style transfer effect of user portrait.

- Finally, in the "Curator" function, users can see the excellent works of other people from previous events, while in the "Personal center", users can see their own generated artworks exhibition.

5. Conclusion

In this study, we constructed an interactive learning system for children's art education. The system allows children to learn about famous paintings through interaction, in order to provide a rich and diverse learning experience. Through this research, we created an engaging way of art learning for children, which increased the motivation and interest in their learning process.

In the future, we plan to further improve the learning experience of the system in the follow aspects:

- Collect more painting images to expand the dataset.
- Explore more innovative interactive learning modules, such as audio guidance and sentiment analysis, to create multidimensional sensory experience.
- Introduce intelligent recommendation algorithms to customize personalized learning plans and recommended content based on users' interests and learning history.

6. Acknowledgments

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