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The Research on Image Inpainting Development

Haoyang Zeng

University of Electronic Science and Technology of China (UESTC), Chengdu 611731, Sichuan, China

*Corresponding author. E-mail: 2018190503027@std.uestc.edu.cn

Abstract

This paper mainly describes the technology and development of image inpainting technology. Firstly, the traditional image inpainting methods are introduced, including diffusion-based method and sample-based method. Then there are three mainstream image inpainting methods summarized on the basis of deep learning, with emphasis on the image inpainting method based on the generated model. Finally, the development and improvement of image restoration are prospected.

Keywords

Image Inpainting, Deep Learning, Model Generation.

1. Introduction

Image inpainting is a kind of skill segment which infers and repairs the contents of damaged or missing areas according to the known content of the image, so as to make the repaired image meet the needs of human visual perception as much as possible. The work originated in the Middle Ages, when restorers manually restored damaged art images with personal experience and rich imagination. Image inpainting has been one of the issues that researchers focus on.The traditional image inpainting is based on image content similarity and texture consistency, using the method based on mathematical and physical theory, through the establishment of geometric model or texture synthesis to complete the small area damaged image restoration. However, due to the lack of image comprehension and perception like human beings, the results often have some problems, such as fuzzy content, lack of semantics etc.In recent years, machine learning technology, represented by deep learning technology, has made a qualitative leap, and a series of achievements have been achieved in many research fields. Among them, Convolutional Neural Networks(CNN), as a feedforward depth network, has a strong ability to learn and express image features, and also has excellent performance in large-scale image processing. On the other hand, Generative Adversarial Networks(GANs) proposed by Goodfellow has been widely used in the field of computer vision because of its ingenious game confrontation learning mechanism and great potential to fit data distribution. These research results greatly make up for the deficiency of traditional methods in image vision task in image semantic understanding, and to some extent solve the semantic gap between low-level features and high-level semantics of images. as a result, deep learning technology gradually occupies the forefront of the field of computer vision . Among them, image inpainting based on deep learning has also set off an upsurge of research and achieved remarkable results.

2. Traditional Image Inpainting Methods

The traditional image inpainting methods are mainly based on the correlation and content similarity between image pixels. According to the different restoration optimization criteria, they can be broadly divided into sample-based methods and diffusion-based methods.

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2.1 Sample-based Method

The sample-based method assumes that the missing region of the image can be represented by known samples, and this method can achieve a better effect in repairing the damaged image in a large area, not only filling the missing area of any size, but also repairing the texture details of the damaged part. [1] These methods mainly include image inpainting algorithm based on texture synthesis and image inpainting algorithm based on data drive.

2.2 The Diffusion-based Method

The diffusion-based method is mainly used to repair small-scale image damage, such as small scratches in photos. The main idea of this kind of method is to imitate the process of repairing the image manually by the art restorer. According to the edge information of the region to be repaired, a method from coarse to fine is used to estimate the direction of the isoluminance line. [2] The propagation mechanism is used to propagate the known information to the area to be repaired to achieve image restoration.

3. Image Inpainting Method based on Deep Learning

With the development of deep learning technology and the improvement of the advanced hardware equipment, in recent years, researchers have introduced deep learning technology into image inpainting, and proposed many image inpainting methods based on deep learning. [3]According to the different model structure, image inpainting methods based on deep learning can be divided into three categories: image inpainting methods based on generating model, the image inpainting method based on self-coding and image inpainting methods based on network structure.

3.1 Image Inpainting Method based on Generating Model

The method of image inpainting based on generating model refers to training the ability to generate powerful images of the model. At present, the most representative models are autoregressive model, VAE model and GAN model.Table 1 lists some representative algorithms based on generation models.

Table 1. Summary of image inpainting method based on generating model

Algorithm name	Year / Source	Generation model	Innovation of model structure
PixelRNN[4]	2016/ICML	Autoregressive model	Two-dimensional RNN structure to generate images pixel by pixel
DGM[5]	2017/CVPR	GAN model	Using the characteristics of GAN, we can directly convert noise into image for image restoration.
CVAE-GAN[6]	2017/ICCV	VAE model, GAN model	Combined with VAE and GAN, it is composed of encoder, generator, classifier and discriminator.
PICNet[7]	2019/CVPR	VAE model, GAN model	With the combination of VAE and GAN, the network / generation network is reconstructed and the diversity repair is realized in parallel.
PGGAN[8]	2020/CVPR	GAN model	Two-stage training, introducing a priori structure to repair higher resolution images
UCTGAN[9]	2020/CVPR	GAN model	Multi-module and double-branch to realize multiple repair

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The methods in the literature contain complex iterative optimization reasoning process when finding the prior distribution that best matches the damaged image, so there are still limitations in the restoration of high-resolution images. In order to speed up the reasoning process and extend the image method based on generating model to higher resolution image inpainting tasks, Lahiri et al. designed a two-stage training strategy that combines GAN network and depth neural network: in the first stage, a GAN network is trained to map noise distribution to natural images. In the second stage, the GAN network pre-trained in the previous stage is fixed, and a depth neural network used to predict the noise prior of the input image is trained to deduce the noise prior that best matches the input image. Finally, the GAN network is used to generate a complete image. This method also introduces a structural prior, which can help the model retain face posture information in the face image inpainting task, so as to generate more real image content.Compared with the image inpainting method based on self-coding, the method based on generation model can realize diversity inpainting. However, due to the problems such as unstable training and prone to pattern collapse in the generated model, this method can only deal with low-resolution images at present.

3.2 Image Inpainting Methods based on Self-Coding

In recent years, researchers have tried to apply the Encoder-Decoder structure in the self-coding network to the image restoration task, capturing the context information around the missing area of the image through the encoder and encoding it. Extract the latent feature representation of the image, restore the original image data through the decoder to generate the content of the missing region, and continuously optimize the restoration results by adding various constraints or with the help of the idea of GANs generation confrontation, and then propose a large number of image restoration methods based on self-coding. [10] It can also be subdivided into methods based on network optimization, methods based on attention mechanism and methods based on structural information constraints.

3.3 .Image Inpainting Methods based on Network Structure

According to the literature, the excellent performance of deep convolution network in the field of image generation and inpainting is mainly due to its ability to learn prior knowledge from a large number of image data samples. however, the deep generation network already has the ability to capture a large number of low-level image statistics before any learning, that is, these statistics can be captured by the structure of the deep convolution network. Instead of learning from large-scale image data sets. For this reason, it provides a new repair idea, which uses a randomly initialized untrained generation network to fit the image to be repaired, trains the known content of a single damaged image, and takes the network structure itself as the only prior information. constantly iterate and inversely deduce the content of the missing region of the image. This kind of repair idea is very ingenious, and it is very suitable for the image inpainting problem which is difficult to get the image training set, but the amount of calculation is large, and the restoration of a single image needs thousands of iterations.

4. Prospects for Future Development

In this paper, on the basis of classifying and summarizing the existing image inpainting methods, aiming at the problems and difficulties still existing in the current research task, the future research direction and development trend are prospected as follows:

(1) the essence of image inpainting is to mine the known information to identify the missing areas. A computer vision task for speculative completion of content. To achieve the effective extraction of known information and establish information association with unknown content is an inevitable requirement to improve the quality of repair. Therefore, in the follow-up research, the characteristic of the inpainting model to the image is improved. Expression learning ability is still one of the problems worthy of in-depth exploration.

(2) the multi-step repair method can achieve progressive repair from coarse to fine, but this model has some defects that can not be ignored, such as the increase of computing resources, the adverse

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effects between different repair stages and the increase of training difficulty. In the future research, it is still a research hotspot to establish an end-to-end single-step inpainting model and adopt the internal optimization mode to achieve high-quality image inpainting with consistent texture, coherent structure and clear semantics.

(3) Image inpainting is a research task oriented to the needs of practical applications, and in practical applications, the damaged area is usually in an unknown state. Therefore, blind repair will be a trend of future research.

(4) with the improvement of hardware technology, the image inpainting has been greatly improved, as the current restoration is mainly low-resolution images. So in the future, the aim is to achieve higher resolution image inpainting, mainly fine-grained inpainting.

(5) Generating countermeasure network plays a key role in image generation, and the most widely used one is generating countermeasure network, but there are still many problems, such as mode collapse and unstable training. These problems are still waiting to be improved in the future.

5. Conclusion

With the arrival of big data era, the improvement of hardware computing power, and the urgent application demand, the repair task of "large area missing image" has been widely concerned by academia and industry at home and abroad. it has become an important and challenging research topic in the field of computer vision. The image inpainting method based on deep learning mainly relies on the coherence of image structure and content similarity, and relies on the strong expression and learning ability of convolution network to express image features and the ability to generate antagonistic network to fit the probability distribution of data. This method has become the mainstream method in the field of image restoration.

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