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Topic 01:Image inpainting.

Review:

Image inpainting refers to the process of filling- in missing data in a designated region of the visual input. The object of the process is to reconstruct missing parts or damaged image in such a way that the inpainted region cannot be detected by a causal observer. Image inpainting has been widely investigated in the applications of digital effect (e.g., object removal), image restoration (e.g., scratch or text removal in photograph), image coding and transmission (e.g.,recovery of the missing blocks), etc. The most fundamental inpainting approach is the diffusion based approach , in which the missing region is filled by diffusing the image information from the known region into the missing region at the pixel level. These algorithms are well founded on the theory of partial differential equation (PDE) and variational method. The diffusion-based inpainting algorithms have achieved convincingly excellent results for filling the nontextured or relatively smaller missing region. However, they tend to introduce smooth effect in the textured region or larger missing region. The second category of approaches is the examplar-based inpainting algorithm. This approach propagates the image information from the known region into the missing region at the patch level. This idea stems from the texture synthesis technique proposed, in which the texture is synthesized by sampling the best match patch from the known region. However, natural images are composed of structures and textures, in which the structures constitute the primal sketches of an image (e.g., the edges, corners, etc.) and the textures are image regions with homogenous patterns or feature statistics (including the flat patterns). Pure texture synthesis technique cannot handle the missing region with composite**.** textures and structures. Bertalmio et al. proposed to decompose the image into structure and texture layers, then inpaint the structure layer using diffusion-based method and texture layer using texture synthesis technique. It overcomes the smooth effect of the diffusion-based inpainting algorithm; however, it is still hard to recover larger missing structures. Criminisi et al.designed in [1]an exemplar-based inpainting algorithm by propagating the known patches (i.e., exemplars) into the missing patches gradually. To handle the missing region with composite textures and structures, patch priority is defined to encourage the filling-in of patches on the structure. Wu proposed a cross-isophotes exemplar- based inpainting algorithm, in which a cross- isophotes patch priority term was designed based on the analysis of anisotropic diffusion. Wong proposed a nonlocal means approach for the examplar-based inpainting algorithm. The image patch is inferred by the nonlocal means nof a set of candidate patches in the known region instead of a single best match patch. More exemplar-based inpainting algorithms were also proposed for image completion.Compared with the diffusion-based inpainting algorithm, the exemplar-based inpainting algorithms have performed plausible results for inpainting the large missing region. Most inpainting methods work as follows. As a first step the user manually selects the portions of the image that will be restored. This is usually done as a separate step and involves the use of other image processing tools. Then image restoration is done automatically, by filling these regions in with new information coming from the surrounding pixels (or from the whole image). In order to produce a perceptually plausible reconstruction, an inpainting technique must attempt to continue the isophotes (line of equal gray value) as smoothly as possible inside the reconstructed region.

References[01]:

A. Criminisi, P. Peres and K. Toyama, "Object Removal by Exemplar-Based Inpainting", Proceedings of the 2003 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'03)

Topic 02: Patch-Based Image Inpainting via Two-Stage Low Rank Approximation.

Review:

To recover the corrupted pixels, traditional inpainting methods based on low-rank priors generally need to solve a convex optimization problem by an iterative singular value shrinkage algorithm. In this paper, we propose a simple method for image inpainting using low rank approximation, which avoids the time-consuming iterative shrinkage. Specifically, if similar patches of a corrupted image are identified and reshaped as vectors, then a patch matrix can be constructed by collecting these similar patch-vectors. Due to its columns being highly linearly correlated, this patch matrix is low-rank. Instead of using an iterative singular value shrinkage scheme, the proposed method utilizes low rank approximation with truncated singular values to derive a closed-form estimate for each patch matrix. Depending upon an observation that there exists a distinct gap in the singular spectrum of patch matrix, the rank of each patch matrix is empirically determined by a heuristic procedure. Inspired by the inpainting algorithms with component decomposition, a two-stage low rank approximation (TSLRA) scheme is designed to recover image structures and refine texture details of corrupted images. Experimental results on various inpainting tasks demonstrate that the proposed method is comparable and even superior to some state-of-the-art inpainting algorithms.

References[02]:

J. C. Huang, C. H. Hwang, Y. C. Liao, N. C. Tang, and T. J. Chen, "Exemplar-based image inpainting base on structure

Topic 03: Texture synthesis based inpainting.

Review:

Texture synthesis based Inpainting Algorithm Texture synthesis algorithms operate essentially on one pixel at a time and determine its value by looking for similar areas in the available image data.

The fragment based algorithms can in some sense be considered as generalized texture synthesis. Instead of copying single pixels whole blocks are transferred into the inpainting domain thereby regarding that the resulting inpainting connects smoothly and is similar to the available image. Some hybrid algorithms which combine one or more techniques can also be used in inpainting domain .In the following we give an overview on texture synthesis algorithms which have been used particularly for inpainting purposes:Cant & Langensiepen create copies of the image to be inpainted at various scales. In the coarsest image several candidates for a best matching patch are searched. In this search process also mirrored and rotated versions of the patches are considered. Once a set of candidate patch positions is found they are transferred to higher levels where the positions are adjusted to the finer resolution by searching in a neighborhood around the best positions found so far. Thus an exhaustive search has only to be performed at the coarsest level, on the finer levels only a small subset of the image has to be considered. Criminisiet.al. and use a confidence and a priority function. The priority of a pixel depends on the confidence and on the gradient magnitude of its surrounding. Pixels lying close to convex corners inside the inpainting domain get high priority since they are surrounded by many high confidence pixels and thus can be reliably inpainted. On the other hand pixels lying close to edges (high gradients) are also assigned high priority such that edges are treated preferably. Continuation of edges tends to build concave spikes into the inpainting domain and the priority of the surrounding pixels decreases. Thus a balanced growing of edges and texture patches is guaranteed. Patches are taken to be fixed size and constant shape (i.e., no rotation or mirroring is considered) and the similarity of patches is simply calculated using sum of squared differences. The edges as well as their infuencing regions are readily restored by structure propagation. Then, in this subsection, the remainder unknown regions are treated as textural regions, so texture synthesis isemployed to fill-in these holes. For textural regions, we prefer patch-wise algorithms because they are good at preserving large-scale texture pattern

References[03]:

H. Yamauchi, J. Haber, H.-P. Seidel, “Image Restoration Using Multiresolution Texture Synthesis and Image Inpainting”, Computer Graphics International, pp.108-113, 2003.

Topic 04: Patch-based Texture Synthesis for Image Inpainting

Review:

Image inpaiting is an important task in image processing and vision. In this paper, we develop a general method for patch-based image inpainting by synthesizing new textures from existing one. A novel framework is introduced to find several optimal candidate patches and generate a new texture patch in the process. We form it as an optimization problem that identifies the potential patches for synthesis from an coarse-to-fine manner. We use the texture descriptor as a clue in searching for matching patches from the known region. To ensure the structure faithful to the original image, a geometric constraint metric is formally defined that is applied directly to the patch synthesis procedure. We extensively conducted our experiments on a wide range of testing images on various scenarios and contents by arbitrarily specifying the target the regions for inference followed by using existing evaluation metrics to verify its texture coherency and structural consistency. Our results demonstrate the high accuracy and desirable output that can be potentially used for numerous applications: object removal, background subtraction, and image retrieval. The proposed framework is evaluated extensively, and the results including comparison to recent state-of-the-art demonstrate that it achieves considerable improvements on both visual and quantitative evaluations.

References[04]:

V. Janarthanan,G. Jananii,” A Detailed Survey on Various Image Inpainting Techniques”, September 2012 , International Journal of Advances in Image Processing, Vol. 2, No. 3

Topic 05: Image Inpainting Using Modified Exemplar- Based Method.

Review:

Inpainting refers to the art of restoring lost parts of image and reconstructing them based on the background information i.e. Image inpainting is the process of reconstructing lost or deteriorated parts of images using information from surrounding areas. The purpose of inpainting is to reconstruct missing regions in a visually plausible manner so that, it seems reasonable to the human eye. There have been several approaches proposed for the same. This paper introduce a new image inpainting approach which include salient structure completion and texture propogation.In salient structure completion step, incomplete salient structures are completed through content based image retrieval technique. In the texture propagation step first synthesizes texture information of completed salient structures. Then the texture information is propagated into remaining missing regions by patch based inpainting method. Inpainting refers to the art of restoring lost parts of image and reconstructing them based on the background information. i.e. image inpainting is the process of reconstructing lost or deteriorated parts of images using information from surrounding areas. In fine art museums, inpainting of degraded painting is traditionally carried out by professional artists and usually very time consuming. The purpose of inpainting is to reconstruct missing regions in a visually plausible manner so that it seems reasonable to the human eye. There have been several approaches proposed for the same. It has made wide area in the field of image processing, such as computer graphics, image editing, film postproduction, image restoration.

References[05]:

Bertalmio, M., Vesa, L., Sapiro, G., et al., 2003. Simultaneous structure and texture image inpainting. IEE Trans. Image Process. 12 (8), 882–889

Topic 06: Region filling and object removal by exemplar-based image inpainting:

Review:

A new algorithm is proposed for removing large objects from digital images. The challenge is to fill in the hole that is left behind in a visually plausible way. In the past, this problem has been addressed by two classes of algorithms: 1) "texture synthesis" algorithms for generating large image regions from sample textures and 2) "inpainting" techniques for filling in small image gaps. The former has been demonstrated for "textures"-repeating two-dimensional patterns with some stochasticity; the latter focus on linear "structures" which can be thought of as one-dimensional patterns, such as lines and object contours. This paper presents a novel and efficient algorithm that combines the advantages of these two approaches. We first note that exemplar-based texture synthesis contains the essential process required to replicate both texture and structure; the success of structure propagation, however, is highly dependent on the order in which the filling proceeds. We propose a best-first algorithm in which the confidence in the synthesized pixel values is propagated in a manner similar to the propagation of information in inpainting. The actual color values are computed using exemplar-based synthesis. In this paper, the simultaneous propagation of texture and structure information is achieved by a single , efficient algorithm. Computational efficiency is achieved by a block-based sampling process. A number of examples on real and synthetic images demonstrate the effectiveness of our algorithm in removing large occluding objects, as well as thin scratches. Robustness with respect to the shape of the manually selected target region is also demonstrated. Our results compare favorably to those obtained by existing techniques.

References[06]:

M. Ashikhmin, "Synthesizing natural textures", *Proc. ACM Symp. Interactive 3D Graphics*, pp. 217-226, 2001-Mar.

Topic 07: Partial Differential Equation (PDE) based inpainting:

Review:

PDE(partial differential equations) is designed to connect edges or isophotes (line of equal gray values). Bertalmio et al.[11] proposed an image inpainting algorithm based on PDE. Its algorithm will have good results if missed regions are small, but in large damaged regions it will take so long time and wont have good results. Bertalmio et al. use similarities between image processing and fluid dynamic topics, and he proposed an image inpainting algorithm using the Navier Stokes equation. Chan et al. present several inpainting algorithms such as total variation (TV), curvature driven diffusion (CDD), and Euler's elastica. The authors try to minimize the TV-norm of reconstructed image in order to restore damaged pixels. Chan and Shen use energy functional involving the curvature of the level curves and tries to connect level curves in a smoothing fashion. Masnou and Morel in present a new model for image inpainting. They propose a simple but effective algorithm to connect level lines. Some works relate phase transition in supper conductors to image inpainting . Authors propose an algorithm that propagates tangential and normal vectors into missed regions then it reconstructs damaged image by fitting it to these vectors. Telea propose a fast marching method that can be considered as a PDE method which is faster and simpler to implement than other PDE based algorithms. All of above mentioned algorithms are very time consuming and have some problems with the damaged regions with a large size. PDE technique has been widely used in numerous applications such as image segmentation, restoration and compression. Even for traditional image inpainting.

References[07]:

H. Yamauchi, J. Haber, H.-P. Seidel, “Image Restoration Using Multiresolution Texture Synthesis and Image Inpainting”, Computer Graphics International, pp.108-113, 2003

Topic 08: Combining anisotropic diffusion, transport equation and texture synthesis for inpainting textured images

Review:

In this work we propose a new **image inpainting** technique that combines texture synthesis, anisotropic diffusion, transport equation and a new sampling mechanism designed to alleviate the computational burden of the inpainting process. Given an image to be inpainted, anisotropic diffusion is initially applied to generate a cartoon image. A block-based inpainting approach is then applied so that to combine the cartoon image and a measure based on transport equation that dictates the priority on which pixels are filled. A sampling region is then defined dynamically so as to hold the propagation of the edges towards image structures while avoiding unnecessary searches during the completion process. Finally, a cartoon-based metric is computed to measure likeness between target and candidate blocks. Experimental results and comparisons against existing techniques attest the good performance and flexibility of our technique when dealing with real and **synthetic images**. ***Texture synthesis algorithms*** rely on the investigation of location and stationariness of texture patterns contained in the image (Efros and Leung, 1999, Efros and Freeman, 2001, Ashikhmin, 2001, Wei, 2002). The inpainting process is carried out by a pixel similarity-based copy-and-paste strategy. The core idea is to find out the group of pixels that best fits into the region to be filled and copy it to that location. This is done by measuring the similarity between group of pixels from the image and on the boundary of the region to be filled. Texture synthesis techniques are effective when the image is made up of a unique texture pattern, but they are prone to fail when multiple textures and homogeneous structures are present in the image simultaneously. The computational cost involved on texture synthesis-based algorithms is also an issue for practical applications.

References[08]:

- D. Calvetti *et al.* Image inpainting with structural bootstrap priors Image Vision Comput. (2006).

Topic 09: Non-Local Image Inpainting Using Low-Rank Matrix Completion

Review:

In this paper, we propose a highly accurate inpainting algorithm which reconstructs an image from a fraction of its pixels. Our algorithm is inspired by the recent progress of non-local image processing techniques following the idea of 'grouping and collaborative filtering'. In our framework, we first match and group similar patches in the input image, and then convert the problem of estimating missing values for the stack of matched patches to the problem of low-rank matrix completion, and finally obtain the result by synthesizing all the restored patches. In our algorithm, how to accurately perform patch matching process and solve the low-rank matrix completion problem are key points. For the first problem, we propose a robust patch matching approach, and for the second task, the alternating direction method of multipliers is employed. Experiments show that our algorithm has superior advantages over existing inpainting techniques. Besides, our algorithm can be easily extended to handle practical applications including rendering acceleration, photo restoration and object removal. In our algorithm, how to accurately perform patch matching process and solve the low-rank matrix completion problem are key points. For the first problem, we propose a robust patch matching approach, and for the second task, the alternating direction method of multipliers is employed. Experiments show that our algorithm has superior advantages over existing inpainting techniques. Besides, our algorithm can be easily extended to handle practical applications including rendering acceleration, photo restoration and object removal.

References[09]:

Ballester C., Bertalmio M., Caselles V., Sapiro G., Verdera J.: Filling-in by joint interpolation of vector fields and gray levels. IEEE Transactions on Image Processing Volume 10, Issue 8 2001, pp.1200-1211.

Topic 10: Patch-Based Image Inpainting with Generative Adversarial Networks.

Review:

Area of image inpainting over relatively large missing re- gions recently advanced substantially through adaptation of dedicated deep neural networks. However, current network solutions still introduce undesired artifacts and noise to the repaired regions. We present an image inpainting method that is based on the celebrated generative adversarial network (GAN) framework. The proposed PGGAN method in- cludes a discriminator network that combines a global GAN (G-GAN) architecture with a patchGAN approach. PGGAN first shares network layers between G-GAN and patchGAN, then splits paths to produce two adversarial losses that feed the generator network in order to capture both local continuity of image texture and pervasive global features in images. The proposed framework is evaluated extensively, and the results including comparison to recent state-of-the-art demonstrate that it achieves considerable improvements on both visual and quantitative evaluations. Image inpainting is a widely used reconstruction tech- nique by advanced photo and video editing applications for repairing damaged images or refilling the missing parts. The aim of the inpainting can be stated as reconstruction of an image without introducing noticeable changes. Al- though fixing small deteriorations are relatively simple, filling large holes or removing an object from the scene are still challenging due to huge variabilities and complexity in the high dimensional image texture space. We propose a neural network model and a training framework that completes the large blanks in the images. As the damaged area(s) take up large space, hence the loss of information is considerable, the CNN model needs to deal with both local and global harmony and conformity to produce realistic outputs.

References[10]:

Barnes, E. Shechtman, A. Finkelstein, and D. B. Goldman. Patchmatch: A randomized correspondence algorithm for structural image editing. ACM Trans. Graph., 28(3):24:1–24:11, July 2009.