

Detailed Survey on Exemplar Based Image Inpainting Techniques

Jaspreet Kaur Chhabra and Mr. Vijay Birchha
 Department of Computer Science and Engineering, R.G.P.V University
 SVCE Indore, India

Abstract- Image inpainting is a technique which is used to patch up the missing area in an image. In early years image inpainting techniques gained the high popularity in the field of image processing, used for restoration of damaged images. The aim of image inpainting is to fill in the missing area in an image which is visible to human eyes. Image inpainting is also applied for reinstallation of old images/films, correction of red-eye, object elimination in digital photographs, removal of spots of dust in image/film, creative effect by removing objects etc. There are different types of image inpainting techniques such as- exemplar based image inpainting, texture synthesis based image inpainting, PDE based image inpainting, hybrid inpainting and Semi-automatic and Fast Inpainting. In this paper we provide a detailed survey on Exemplar based image inpainting.

Keywords-Inpainting, Exemplar Based Inpainting, PDE Based Inpainting, Texture Synthesis, Hybrid Inpainting, Object Removal, Filling Area.

I. INTRODUCTION

In present, the image inpainting technology is a very hot topic in the field of image processing and computer graphics and it has several applications like reformation of old images/films, removal of object in digital photos, super-resolution, image compression, red eye adaptation, image coding and image transmission. Image Inpainting is the technique of repairing of corrupted/selected portion of an image. Based on the background information, image inpainting try to fill the corrupted/missing data in the image. Image reinstallation consists of re-establishment of old images/photographs and damaged image/film by elimination of dust spots, speckles, scratches, superimposed text like dates, subtitles, or publicity. Elimination of unwanted objects from a photograph/image such as elimination of an unwanted thing like a person, animal, tree etc. is known as object removal. The goal of image inpainting is not only to recover the image, but to generate few images that have closely similar with the original image.

There are two types of algorithms that are used in the past to deal with the above cited problems, they are texture synthesis and inpainting. Algorithms that are used for generating large image regions from sample textures are known as texture synthesis algorithms and this algorithm focused on texture part of image. For filling the little image gaps inpainting techniques are used and this techniques focused on the structural part of photograph/image [1].

The mixture of texture synthesis technique and inpainting technique are produces a new inpainting technique known as exemplar based image inpainting technique. That's why

exemplar based image inpainting can rebuild texture part as well as structural part of an image [2]. Figure- 1 shows the example of Exemplar Based Image Inpainting Algorithm.



Figure- 1: Example of Exemplar Based Image Inpainting Algorithm

The rest of the paper is planned as follows. Section-2 discusses about the different image inpainting techniques, Section-3 discusses about related work on exemplar based image inpainting and finally, the conclusion is discussed in section-4.

II. IMAGE INPAINTING TECHNIQUES

There are numbers of image inpainting techniques used in literature, some of them are: Texture synthesis based image inpainting, PDE (Partial Differential Equation) based image inpainting, exemplar based image inpainting, Hybrid inpainting, Semi-automatic and Fast Inpainting.

A. Texture synthesis based image inpainting

Texture synthesis based image inpainting algorithm is one of the earliest techniques of image inpainting. To complete the missing areas these algorithms utilize similar neighbourhoods of the damaged pixels. To create the new image pixels the texture synthesis algorithms use an initial seed. All the earlier inpainting techniques make use of these methods to fill the missing area by sampling and copying pixels from the neighbouring region. For e. g, to model the local distribution of the pixel, Markov Random Field (MRF) is used. Texture synthesis based image inpainting algorithms synthesized the new texture by using querying existing texture and discovering all similar neighbourhoods. Their dissimilarity present mainly in how continuity is preserve between existing pixels and inpainting hole [3].

Texture synthesis based image inpainting algorithms be able to fill large textured areas, but depends on users selection on sampling position and content. Texture synthesis based image inpainting algorithms can be classified into three categories: Statistical (parametric), pixel-based (non-parametric) and patch-based (non-parametric).

B. PDE based image inpainting

Partial Differential Equation (PDE) based algorithms are iterative algorithms which are proposed by Marcelo Bertalmio et al [4]. The main goal of this algorithm is to continue geometric and photometric information that appears at the border of the occluded/obstructed area into area itself and this is made through propagating the information in the direction of minimum change using isophote lines. Partial differential equation algorithms will generate good outcomes if missed areas are small one, but when the missed areas are big partial differential equation algorithms will take so much time and will not generate good outcomes. There are number of applications of partial differential equation based algorithms like image reinstatement, image segmentation etc. The focus of partial differential equation based algorithms is mainly on maintaining the structure of the inpainting area. Thus these algorithms results blurred image. Another problem with these algorithms is that the large textured areas are not well regenerated.

C. Exemplar based image inpainting

The exemplar based image inpainting is an important category of inpainting algorithms. The exemplar based image inpainting is an efficient technique of reinstatement of big target regions. The exemplar based image inpainting is consists of two stages:

1. First priority assignment is made and then
2. Choice of the best matching patch.

The exemplar based image inpainting selects the best matching patches from the well-known area, whose similarity is determined by certain metrics, and insert into the target patches in the missing area. According to the filling order, the technique fills structures in the missing regions using spatial information of neighboring regions [1] [9]. The exemplar based image inpainting consists of the following steps:

- 1) *Initializing the Target Region:* In this step initial missing areas are removed and represented with suitable data structures.
- 2) *Computing Filling Priorities:* In this a predescribed priority function is utilized to compute the filling order for all unoccupied pixels in the starting of each filling iteration.
- 3) *Searching Example and Compositing:* In this the most analogous pattern is found from the source area to compose the given patch, which centered on the given pixel.
- 4) *Updating Image Information:* In this the boundary of the target area and the necessary information for computing filling priorities are changed numbers of algorithms are created for the exemplar based image Inpainting.

D. Hybrid Inpainting

Hybrid inpainting technique is also known as Image Completion. Hybrid inpainting technique is combination of both texture synthesis and partial differential equation based inpainting for completing the missing areas. The core thought behind hybrid inpainting technique is that it divides the image into two separate parts, texture region and structure region [5]. The consequent decomposed areas are filled by edge propagating techniques and texture synthesis techniques. Hybrid inpainting technique is used for filling large missing/target areas. Structure completion through segmentation is one of the important directions in inpainting process, we have to trust. There are two steps in this technique: First one is structure completion followed by texture synthesis and second one is synthesizing texture and color information in every segment, again utilizing tensor voting [6].

E. Semi-automatic and Fast Inpainting

Semi-automatic image inpainting technique needs user's assistance in the form of guide lines to assist in structure completion has found favor with researchers. In a method proposed by Z. Xu and S. Jian [7], present inpainting with Structure propagation, this technique shows a two-step process. In the first stage a user manually gives essential missing information in the gap by sketching object boundaries from the well-known to the unknown area and then a patch based texture synthesis is utilize to produce the texture. Semi-automatic image inpainting technique takes much time from a minute to hours for completion; it depends on the size of area to in paint. To make up the conventional image inpainting algorithms fast, a new class of image inpainting technique is being developed. Fast image inpainting technique based on an isotropic diffusion model which performs inpainting by repeatedly convolving the inpainting area with a diffusion kernel [8].

The fast inpainting techniques are not appropriate in filling the big missing areas as they not have explicit methods to inpaint edge areas. Another drawback of this technique is that it produced blur effect in resultant image.

III. LITERATURE SURVEY ON EXEMPLAR BASED IMAGE INPAINTING

A. Sheetal Badgujar and N. M. Shahane [10]:

In this paper, author enhanced the performance of exemplar based image inpainting algorithm by introducing two different techniques. Both the techniques utilize the patch propagation by internally propagating the image patches from the source area into the interior of the target area patch by patch. In the first technique of exemplar-based image inpainting an easy patch shifting technique is utilized. In traditional exemplar-based inpainting technique errors often arise when little number of well-known pixels is used to represent a big unknown area. The patch shifting technique offers more significant target patch than traditional exemplar-based technique. In this technique, the target patch which has well-known pixels fewer than predefined threshold would be shifted in the way that enhance the number of well-known pixels, means the possibility to filling-in every

patch obviously increase. The second technique of exemplar-based image inpainting utilizes area segmentation. In this technique segmentation map is used to enhance the performance of robust inpainting, in which a segmentation technique is employed to utilize spatial information in the source area. By means of segmentation map, it adaptively finds out patch size and decreases search area. The exemplar-based image inpainting technique offers great outcomes as compare to PDE-based image inpainting technique. This technique reduces the number of iterations and error propagation sourced by inaccurate matching of source patch.

B. G.Anto Silviya and V.R.Bhuma [11]:

In this paper, author enhanced the performance of exemplar based image inpainting algorithm by introducing a new technique with spatiogram. A spatiogram is a photograph/image descriptor. Spatiogram is a mixture of a histogram with the mean & covariance of the location with each other. The unnecessary area such as texts/scratches are eliminated by means of associated neighborhood technique and the filling/completion of missing area/hole in the image is made through Laplacian approximation technique. The image is subdivided into little blocks based on the size of the missing area/hole. The mean shift technique is utilized to assign value to each pixel of the inpainted area based on the pixel coloring happening in the neighborhood pixel. The mean and the covariance of location of each color are correlated to ensure the continuity of the reinstallation of the boundary of the inpainting area. Image is improved by using histogram equalization in order to enhance its quality after filling the inpainted area.

C. Shivani Gaikar and Neha Khairnar [12]:

In this paper, author eliminated the unnecessary objects or data from the original photograph/image but this modification is not observed by the user. Thus this will be made by utilizing the three algorithms that is: Exemplar Based Image Inpainting Technique, DCT (Discrete Cosine Transform) Based Technique and FMM (Fast Marching Method).

Exemplar based image inpainting technique and DCT based technique, which economically and efficiently produce new texture by sampling & copying color values from source. Exemplar based technique and DCT based technique is utilized for eliminating big objects from digital images/photographs and replacing them with visually probable backgrounds. The Fast Marching Method (FMM) is utilized to eliminate all scratches within the photograph/image. This technique has several benefits like- easy to implement, efficient than other inpainting techniques, it generates most similar outcomes than other inpainting techniques and it can be easily adapted to utilize different local inpainting techniques.

D. Sreelekshmi Das and Reeba R. [13]:

In this paper, author presents a robust exemplar-based video inpainting technique that restores the area of the removal object, and the technique can be further

employed to extract the back ground of videos. At first, video is changed into number of frames & object tracking in each frame by utilizing normalized cross correlation. Exemplar-based image inpainting algorithm iteratively finds the source area and fills the missing/damaged area, with the most related patch in the source area. This technique automatically picks the values of parameter for the robust priority function and decrease the search area, with segmentation map. The candidate source areas are discovered by using structure & texture information. This technique can decrease the number of iterations & error propagation caused by inaccurate matching of source patch.

E. Aur'elie Bugeau, Vinh-Thong Ta and Nicolas Papadakis [14]:

In this paper, author suggested a variational exemplar based technique for image colorization. Authors deal with the problem of improving a color image/photograph from a grayscale one. The source image is considered as a reference image/photograph and from which we get input color data. Reconstruction of the lost/missing color of a grayscale pixel is viewed here as the difficulty of automatically picking the best color amongst a set of colors while concurrently ensures the local spatial coherency of the recreated color information. To solve the above problem, authors propose a variational exemplar based technique in which a specific energy is devised to model the color choice and the spatial constraint problems at the same time. At first, a variational formulation model for the color selection difficulty under spatial constraints & then a minimization method which permits computing a local minimum of the described non-convex energy. At last, combine distinct patch-based features & distances in order to create a consistent set of probable color candidates. This set is utilized as input data and our energy minimization permits to automatically pick the best color to move for every pixel of the grayscale image/photograph. This technique generates visually plausible colorization outcomes and can be competitive with other complex techniques proposed in the past.

F. Nikhil Sharma and Niharika Mehta [15]:

In this paper, author presents implementation of Criminis's technique for eliminating large objects from digital images/photographs [1] and then improves it with Cheng's robust algorithm [22]. Criminis's technique utilizes an exemplar-based synthesis technique transformed by an integrated scheme to find out the fill order of the target area. Confidence values of pixels are maintained, along with image isophotes, that together influence filling priority. Criminis's technique is proficient in transmitting both linear structure & 2-dimensional textures into target area with one, simple algorithm. Comparative experiments show that a simple selection of the fill order is necessary and sufficient to handle this task. Cheng developed a generic priority function to facilitate the image restoration. The algorithm proposed by author is more

efficient in both visual quality perfection & user preference consideration. The computational difficulty of the algorithm suggested by author is directed by two assignments: exemplar search & the component weight selection.

G. Manali Desai [16]:

In this paper, author presents an adapted fast and improved exemplar based image inpainting technique to solve the unknown row filling difficulties. This modified technique is adaptation in updating criteria in fast and enhanced exemplar based image inpainting algorithm proposed by Anupam [21]. In [21], author presents a technique that give the answer to the problem, if two or more than two patches have same mean square error, so to choose patch which is most appropriate for the patch to be filled is made by calculating variance. Reduced search area is suggested, in order to decrease the computational difficulty instead of finding in whole image. The proposed algorithm resolve the difficulty of unknown row filling and provides better results than original fast and enhanced exemplar based image inpainting algorithm. But the resultant images produced by this approach still suffer from some difficulties due to which it adds few unwanted incorrect information from background in the photograph/image.

H. K. Sangeetha, Dr. P. Sengottuvelan and E. Balamurugan [17]:

In this paper, author presents a new exemplar based inpainting algorithm with an enhanced priority term that describes the filling sequence of patches in the photograph/image. The proposed algorithm is based on patch transmission by inwardly transmitting the image patches from the source area in to the inside of the target area patch by patch.

The exemplar based image inpainting algorithm with best patch match is introduced in this work and for obtaining this best patch match an enhanced patch priority term and a suitable search region is introduced. This research is not only limited to construct the damaged area or the matching area complete accurately, but also repair the image's minute spots, scratches & the big damaged area completely. The results of proposed method show that it has an obvious enhancement in visual quality as compared to the conventional exemplar-based image inpainting algorithm. This work deal with inpainting of images/photographs, it can also be expanded for inpainting of video frames.

I. Waykule J.M. and Patil V.A. [18]:

In this paper, author presents a new algorithm for eliminating big objects from digital photographs/image. In the past, the problem of fill in the gap/hole that is missing in a visually possible way has been deal with by two categories of algorithms: texture synthesis and inpainting. In this paper, authors present a new and efficient algorithm that unites benefits of both approaches. This technique utilizes an exemplar-based texture synthesis technique adapted by a unified method for finding the fill order of the target

area. Together with image isophotes, pixels maintain a confidence value and manipulate their fill priority. In this the resultant image the chosen object has been changed by a visually probable background that imitates the appearance of the source area. This technique is proficient in transmitting both linear structure & 2-dimensional textures into target area with one, simple algorithm.

J. Shilpa J. Kale and P.D.Gawande [19]:

In this paper, author presents a novel and efficient algorithm for eliminating big objects from digital photographs/images that unites benefits of both approaches- inpainting & texture synthesis. At first remind that exemplar based texture synthesis image inpainting includes essential procedure required to imitate both texture and structure, but the success of structure propagation is extremely dependant on the arrangement of filling progress. In this algorithm self-confidence in the synthesized pixel values is transmitted in a way that they related to the transmission of information in inpainting. Exemplar based synthesis is utilized for computing the definite color values. The simultaneous transmission of texture and structure information is obtained by a single, efficient algorithm and the computational efficiency is obtained by a block-based sampling procedure. In this the resultant image the chosen object has been changed by a visually probable background that imitates the appearance of the source area. For exemplar based image inpainting, this is a robust algorithm, which can be modified to any photograph/image contents of diverse characteristics. One significant parameter of this approach is the size of the patch, if the size of patch is bigger, then the filling rate is high and the algorithm is more efficient.

K. Jason C. Hung, Chun-Hong Hwang, Yi-Chun Liao, Nick C. Tang and Ta-Jen Chen [20]:

In this paper, author expands an exemplar based image inpainting technique by integrating Bézier curves to build missing edge information. The foundation of this technique is the contour lines restoring and exemplar based image inpainting technique. In this approach at first, make use of mean shift segmentation to understand color segmentation in damaged photograph/image. Then, Bézier curve is utilized to join the missing contour lines to rebuild main structure in damaged area. At last, use the exemplar based image inpainting technique to locate a best related patch from other source area which holds "real" information and attach it into corresponding location.

IV. CONCLUSION

Recently, image inpainting is very significant area for researchers in image processing. It is applied in various fields like for reinstallation of old images/films, correction of red-eye, object elimination in digital photographs, removal of spots of dust in image/film, creative effect by removing objects etc. This paper provides a detailed survey on exemplar based image inpainting techniques used in literature. Most of the techniques other then exemplar

based image inpainting techniques work for little scratch areas or little areas to be inpainted. In future we will build an approach based on exemplar based image inpainting which works better than existing image inpainting techniques.

REFERENCES

- [1] A. Criminisi, P. Perez and K. Toyama, "Region Filling and Object Removal by Exemplar Based Image Inpainting", IEEE Transactions on Image Processing, 13(9), pp. 1200-1212, 2004.
- [2] Jayesh Patel and Tanuja K. Sarode, "Exemplar based Image Inpainting with Reduced Search Region", International Journal of Computer Application, Vol. 92 – No.12, April 2014.
- [3] Nirali Pandya and Bhailal Limbasiya, "A Survey on Image Inpainting Techniques", International Journal of Current Engineering and Technology, Vol.3, No.5, December 2013.
- [4] Marcelo Bertalmio, Luminita Vese and Guillermo Sapiro, "Simultaneous Structure and Texture Image In painting", IEEE transactions on image processing, Vol. 12, 2003.
- [5] Rane S, Sapiro G and Bertalmio M., "Structure and texture filling of missing image blocks in wireless transmission and compression applications", IEEE transactions on image processing, 2002.
- [6] Ankur G. Patel, Shashwat kumar and Ankit D. Prajapati, "Analysis of Exemplar Based Image Inpainting", International Journal of Computer Science and Information Technologies, Vol. 5 (1), 800-804, 2014.
- [7] Z. Xu and S. Jian, "Image inpainting by patch propagation using patch sparsity", IEEE transactions on image processing, Vol. 19, pp. 1153-1165, 2010.
- [8] M. Oliviera, B. Bowen, R. Mckenna and Y. S. Chang, "Fast Digital Image Inpainting, Processing of International Conference on Visualization, Imaging And Image Processing (VIIP)", Page 261266, 2001.
- [9] Komal s Mahajan and Prof. M. B. Vaidya, "Image in Painting Techniques: A survey", IOSR Journal of Computer Engineering (IOSRJCE), ISSN: 2278-0661, ISBN: 2278-8727 Volume 5, Issue 4, PP 45-49, (Sep-Oct. 2012).
- [10] Sheetal Badgujar and N. M. Shahane, "Exemplar-based Image Inpainting and Approaches to Improve the Performance", International Journal of Computer Applications (0975 – 8887), 2013.
- [11] G.Anto Silviya and V.R.Bhuma, "Exemplar-Based Image Inpainting by Laplacian Approximation Method Using Spatiogram", International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622.
- [12] Shivani Gaikar, Neha Khairnar, Nikita Rane and M. J. Surti, "Image Inpainting using Exemplar based, DCT and FMM Algorithm", International Conference of Advance Research and Innovation, ISBN 978-93-5156-328-0, 2014.
- [13] Sreelekshmi Das and Reeba R., "Robust Exemplar based Object Removal in Video", International Journal of Scientific Engineering and Research (IJSER), ISSN (Online): 2347 - 3878, Volume 1 Issue 2, October 2013.
- [14] Aur'elie Bugeau, Vinh-Thong Ta and Nicolas Papadakis, "Variational Exemplar-based Image Colorization", HAL 00803219, Version-1, March-2013.
- [15] Nikhil Sharma and Niharika Mehta, "Region Filling and Object Removal by Exempeler Based Image Inpainting ", International Journal of Inventive Engineering and Sciences (IJIES) ISSN: 2319–9598, Volume-1, Issue-3, February 2013.
- [16] Manali Desai, "Modified Fast and Enhanced Exemplar based Inpainting Algorithm for Solving Unknown Row Filling Problem", International Journal of Computer Applications (0975 – 8887, Volume 56– No.9, October 2012.
- [17] K. Sangeetha, Dr. P. Sengottuvelan and E. Balamurugan "A Novel Exemplar based Image Inpainting Algorithm for Natural Scene Image Completion with Improved Patch Prioritizing", International Journal of Computer Applications (0975 – 8887) Volume 36– No.4, December 2011.
- [18] Waykule J.M. and Patil V.A., "Region Filling and Object Removal by Exemplar-Based Image Inpainting", International Journal of Scientific & Engineering Research, ISSN 2229-5518, Volume 3, Issue 1, January- 2012 .
- [19] Shilpa J. Kale and P.D.Gawande, "REGION FILLING AND OBJECT REMOVAL BY EXEMPLARBASED IMAGE INPAINTING", International Journal of Advanced Engineering Research and Studies, E-ISSN2249–8974,Vol. 1, Issue 2, January-March, 2012.
- [20] Jason C. Hung, Chun-Hong Hwang, Yi-Chun Liao, Nick C. Tang and Ta-Jen Chen, "Exemplar-based Image Inpainting base on Structure Construction", JOURNAL OF SOFTWARE, VOL. 3, NO. 8, NOVEMBER 2008.
- [21] Anupam, Pulkit Goyal and Sapan Diwakar, "Fast and Enhanced Algorithm for Exemplar based Image Inpainting", Fourth Pacific Rim Symposium on Image and Vedio Technology, 2010.
- [22] W. H. Cheng, C. W. Hsieh, S. K. Lin, C. W. Wang, and J. L. Wu, "Robust algorithm for exemplar-based image inpainting", Processing of International Conference on Computer Graphics, Imaging and Vision 2005, pp. 64–69, Beijing, China, Jul. 2005.