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Image Inpainting Using Cubic Hermite Spline Technique

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Abstract:— **Image inpainting is popularly used to automatically recover the damaged or missing regions in digital images and is used to remove the unwanted objects from images. This paper presents a technique for recovering the curves of damaged regions of digital images using cubic splines. The proposed technique is divided into two steps. In the first step the curved structure of the object in the damaged region is recovered using splines. The user marks a reasonable number of points on the structure of the object around the damaged region. Using these points a spline is constructed and the isophote lines arriving at the contours of the damaged region are interpolated into the damaged regions using that spline. After recovering the structure of the object in the damaged or missing region, in the second step, a fill in process is done to fill in the color information in the damaged region. Any inpainting technique can be used in the second step to fill in the texture information into the damaged region. The proposed algorithm is tested over a large variety of images and has shown excellent results.**

Keyword:-- **Image Inpainting, Image Restoration, Image Retouching**

I. INTRODUCTION

Image inpainting, also known as image retouching, is one of the important topics in image processing, which can be applied in many areas, from the automatic restoration of damaged photographs to removal of unwanted objects in images. It is used to restore the damaged or missed regions in digital images from information in surroundings in such a way that is undetectable to the viewer who has not seen the original image. Reconstruction methods use information from outside of the damaged area for interpolating missing pixels. The application of inpainting are numerous: text removing, old photo scratch restoring and different artistic film effects. The main purpose of image inpainting is filling-in holes in an image using the information from neighbouring regions. The holes may correspond to missing parts or removed objects from the image.

It was Bertalmio et al who invented the terminology of inpainting. They proposed the first technique that, after the selection of the damaged region by the user, automatically recovers the target region. This was an impressive technique and was followed by many other methods. This technique is known as BSCB method, after the names of the authors (Bertalmio, Sapiro, Caselles and Ballesterm). BSCB method is based on first order Partial Differential Equation (PDE).

After BSCB many techniques like were introduced, all based on partial differential equations. After manual selection of the regions to be restored, the BSCB method automatically recovers the damaged pixels from the information in its surroundings. The basic idea of BSCB method is to extend the edges and colours into the target region (region to be restored). It uses gradient direction of the pixels at the boundary of the target region to compute the direction of the edges. Chan and Shen proposed the Total Variational (TV) model which is an extension of BSCB method. TV model is based on the classical total variational model, employs anisotropic diffusion. The curvature driven diffusion (CDD) model [8] is an extended form of TV model and it removed the lacks of TV model. It can restore the larger damaged regions and it can reconnect the broken edges as well.

The image inpainting methods can be classified into the several groups: based on geometry, statistics, sparsity, exemplars and edges detection methods. The geometry-based methods for image reconstruction use partial differential equations (PDE) and restore missing pixels by a diffusion process. These methods have some drawback comprising structure and texture blurring. The PDEs methods are more suitable for removal of scratches and small defects on the images. Statistical-based methods use Markov random field or texture synthesis approach. These algorithms show good results for a stochastic texture and fail in curved edges reconstruction. Sparsity-based methods often blur texture and structure in a recovery of large missing areas. Also this method is computationally complex.

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The exemplar-based approaches use a non-parametric sampling. The basic idea is searching similar patches and copying them from the true image. The main drawback is limitation to inpaint curvy structures. In many cases cannot be found similar patches because the patch size is large or singular. Nowadays, various image inpainting algorithms based on combinational edge and texture reconstruction have been developed. They show high quality results, but require a significant computational time to inpaint large missing areas.

One of the current trends is the development of methods based on contour models, that is, the boundaries of the interpolation, for visual analysis is first necessary to correctly restore the most informative part of the image - object structure. An analysis of this classification leads to the conclusion that at the present time are promising methods, which use combined local and global properties of the image. These properties include texture and contour characteristics.

Splines are vastly used in image processing and signal processing. Splines are used in image morphing techniques and in snakes and contour modelling. Stock used Splines to the calculation of bacterial swimming speed distribution. A multi-resolution Spline technique was introduced in that combines two or more than two images into a larger image mosaic.

Splines are used in image registration developed a framework for image registration using B-Spline. B-Spline is also used in shape modelling. Splines are used in elastic registration methods. The technique exploits the power of Splines to restore the damaged regions. A number of experiments carried out to demonstrate the efficacy of the proposed algorithm.

II.LITERATURE SURVEY

This paper describes a method and algorithm obtaining a consistent image (and video completion). The author proposes a modification of an image inpainting algorithm based on texture and structure reconstruction. Proposed method allows removing static (and dynamic) objects and restoring missing regions using information from neighboring frames. A machine learning approach for no-reference visual quality assessment for image (and video) inpainting is focused in this paper. Experimental methods demonstrate the effectiveness of the proposed approaches.

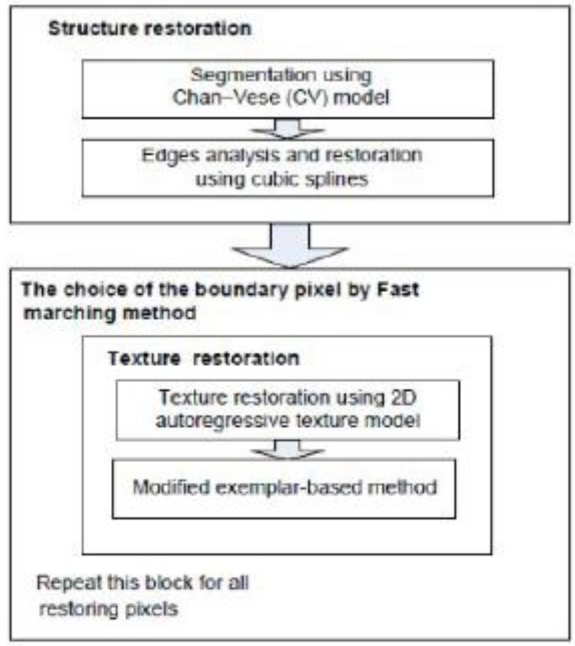

Fig. 1 The proposed approach

This paper describes a framework consistent image completion and no-reference quality assessment. The proposed inpainting algorithm is a modification of the patch based approach with ability for texture synthesis and curved structure interpolation. The no-reference inpainting quality assessment technique is based on a machine learning approach. They have demonstrated that the predicted quality value highly correlates with that of the qualitative opinion in a human observer study. Experimental comparisons to state-ofthe- art inpainting methods demonstrate the effectiveness of the proposed approach.

[2] Image inpainting is a technique used to automatically restore the damaged or missing regions in the images and can also be used to remove the unwanted objects from images. This paper presents an approach for recovering the damaged regions of digital images using Splines. The proposed technique is made of two steps. The first step restores the structure of the object in the damaged region using Splines.

The animator marks a number of points on the structure of the object around the damaged region. Using these points a Spline is constructed and the isophote lines arriving at the contours of the damaged region are interpolated into the damaged regions. After recovering the structure of the object

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in the damaged region, the second step, is a fill in process is done to fill in the colour information in the damaged region. Any interpolation technique can be used to flow the colour information into the damaged region. The proposed algorithm is tested over a large type of images and has given excellent results to restore the small damaged regions.

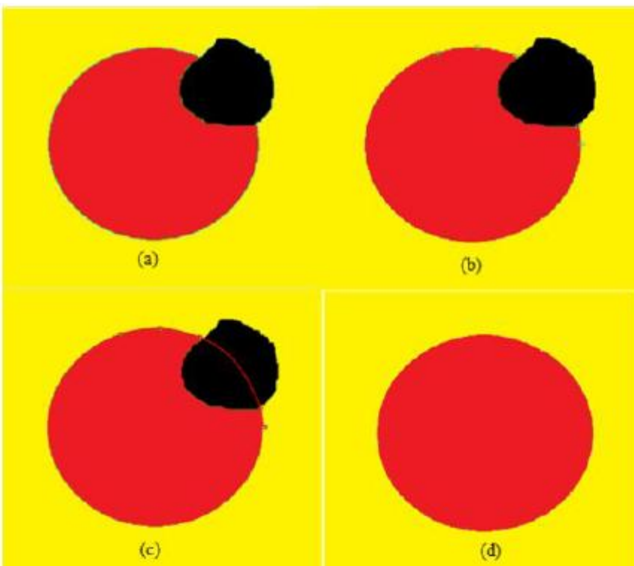

Fig. 2 (a) Damaged image. (b) Points represented by stars to construct the CHS. (c) Red line is the line interpolated by CHS. (d) Image after restoring the damaged region.

This paper presents a simple algorithm for image inpainting. The approach used here is Cubic Hermit Spline to remove the unwanted regions from the images. The structure of the object in the damaged or unwanted region is interpolated using Cubic Hermit Spline and the recovered regions are filled in by a simple colour filling techniques. The algorithm recovers the damaged regions containing simple structure in them, experiments reviles its efficiency.

[3] In this paper interpolation techniques are studied and presented. They are compared on the basis of accuracy and computational efficiency of the techniques. Interpolation is the process of determining the values of a function at given positions lying between its samples. It achieves this process by fitting a continuous function through the available discrete input samples. This also permits input values to be evaluated at arbitrary positions in the input, just not those defined at the sample points. Sampling generates an infinite bandwidth signal, while interpolation plays an opposite role: it reduces the bandwidth of a signal by using a low-pass filter for the discrete signal. That is, interpolation helps in reconstructing the signal lost in the sampling process by smoothing the available data samples with an interpolation function. The process of interpolation is one of the basic operations in image processing. The image quality highly depends on the interpolation technique used. The interpolation techniques are divided into two categories, deterministic and statistical interpolation techniques. The deterministic interpolation techniques assume certain variability between the sample points, such as linearity in case of linear interpolation. Wherein, statistical interpolation methods approximate the signal by minimizing the estimation error. This process may result in original sample values not being replicated, but these are computationally inefficient.

In this paper, for gridded data, the n-dimensional interpolation function can be described as the product of n one-dimensional interpolation functions. Therefore from this we can consider one dimensional interpolation functions to discuss the behaviour of the n-dimensional interpolation functions. Several interpolation techniques have been developed and can be found in the literature of this paper. The most commonly used methods are the nearest neighbour, linear and Spline interpolation techniques. Less used methods are the polynomial and Lagrange interpolation methods.

[4] A mechanism for switching between the continuous and discrete signal domains is a fundamental issue in signal processing. Main examples in image processing are the detection of edges through the computation of gradients and geometric transformation such as rotations and scaling. In this paper the approach to those problems is provided by Shannon's sampling theory which describes a equivalence between a band limited function and its equidistant samples taken at a frequency that is superior or equal at the Nyquist rate. Disadvantages are, firstly that it relies on the use of ideal filters, which are devices not commonly found in nature.

Secondly the band limited hypothesis is in contradiction with the idea of definite signal. Thirdly the band-limiting operation tends to generate Gibbs oscillations which can be visually disturbing in images. Finally, the underlying cardinal basis function has a very slow decay, which makes computations in the signal domain very inefficient. The goals considered in this paper are to provide a tutorial on Splines, to gather all their important properties and providean overview of the mathematical and computational tools available and to give a review of the primary applications of Splines in signal and image processing.

In this paper we see the, continuous representation of discrete signal by fitting it with a Spline. Splines have less of tendency to oscillate. Polynomial Splines can be expressed as linear combinations of B Spline basis functions for equally spaced knots, the Spline parameters may be determined by simple digital filtering, no need of matrix manipulation. Main reason for working with the B-Spline representation is that the B-Splines are compactly supported. They are the shortest functions is a key consideration for computational efficiency. Simple analytical form helps greatly for manipulation. Splines are smooth and well behaved functions they have excellent approximation properties. Precise convergence rates and error estimates are available. Splines have multi-resolution properties that make them very suitable for constructing wavelet bases and also for performing multi- scale processing. B-Splines and their wavelet counterparts have excellent localization properties. Splines provide design flexibility. Sampling procedures can be modified to obtain a Spline representation of an analog signal.

Replacing Shannon's ideal low pass filter with an optimal prefilter specified by the representation MHAMMAD SARFRAZ et.al [5], this author proposes an technique for the outline capture of planar images. This algorithm is stimulated by a global optimization algorithm based on multilevel coordinate search (MCS). By starting a search from certain good points, an enhanced convergence result is obtained. The whole technique has various phases including extracting outlines of images, detecting corner points from the detected outline, applying curve fitting, and addition of extra knot points when needed. The idea of multilevel coordinate search is been used to adjust the shape parameters in the description of the generalized Cubic Spline introduced. The Spline method ultimately produces optimal results for the estimated vectorization of the digital contour obtained from the shapes. It provides an ideal fit as far as curve fitting is concerned. The proposed algorithm requires no human intervention. Some arithmetic and pictorial results are also proved to support the proposed technique.

A global optimization technique, based on multilevel coordinate search, is proposed in this paper for the outline capture of planar images. The proposed technique uses the MCS to optimize a Cubic Spline to the digital outline of images. By starting a search from certain good points an improved convergence result is achieved. The overall technique has various phases. The idea of MCS has been used to optimize the shape parameters in the description of the generalized Cubic Spline introduced. It provides an optimal fit with an efficient computation cost as far as curve fitting is concerned. The proposed algorithm is fully automatic. Implementation details are sufficiently discussed using both with and without insertion of intermediate points. The proposed technique has been supported with numerical and pictorial results demonstrated.

[6] In this paper author proposes a different colour correction scheme for image stitching where the colour map transfer is modelled by a monotone Hermite Cubic Spline and smoothly broadcasted into the target image. A three segments monotone Cubic Spline minimizing colour distribution statistics and gradient differences with respect to both the source and target images is used. The Spline model can handle non-linear colour maps, the minimization over the gradient differences limits robust alterations on the image structure. Adaptive heuristics are introduced to reduce the minimization search space and thus computational time. Experimental comparisons with respect to the state-of-the-art linear mapping models show the validity of the proposed approach.

This paper describes a novel colour correction method for image stitching, which adopts a Spline model and can handle non-linear colour map functions. Different heuristics have been introduced to reduce the model search space and the computation time. The comparison with state-of-the-art colour correction algorithms shows the robustness and the validity of the approach. Future work will include testing adaptive block shapes according to the image segmentation and further computation speed-up improvements.

III. MOTIVATION

Inpainting is the process of reconstructing lost or deteriorated parts of images and videos. In the museum world, in the case of a valuable painting, this task would be carried out by a skilled art conservator or art restorer. In the digital world, inpainting (also known as image interpolation) refers to the application of sophisticated algorithms to replace lost or corrupted parts of the image data.

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Image inpainting is mostly used for the objects with straight edges; this has motivated me to work the similar techniques using cubic hermit spline for curved edges of the objects. The quality assessment of the restored image is carried out using the spectral representation which is also an improved way of assessing the images.

IV. PROPOSED METHODOLOGY

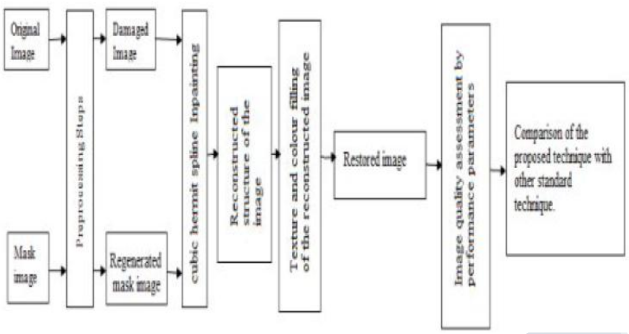

Fig.1: Proposed technique.

Fig.1 shows the detailed block diagram approach for the proposed technique. The original images are clean images and the damage is created in the pre-processing block. We obtain damaged image and regenerated mask image after pre-processing steps. Output of pre-processing block is given as input to cubic Hermit spline Inpainting algorithm, where the structure of the image is reconstructed. The texture filling can be done by using spatial domain image inpainting techniques. The quality assessment of the restored image can be done by several performance parameters. Further, proposed technique can be compared with other standard techniques. Input images for the proposed technique are acquired by using a camera with 15 Mega Pixels resolution.

Interpolation is the process of estimating the intermediate values of a continuous event from discrete samples. Interpolation is used extensively in digital image processing to magnify or reduce images and to correct spatial distortions. Cubic interpolation can be used to estimate the value of damaged pixel for image inpainting. This can be done by convolving the damaged image with cubic convolution interpolation kernel. Let us consider the value of m=2 (kernel size).

The cubic convolution interpolation kernel is composed of piecewise cubic polynomials defined on the subintervals (- 2, - l), (- 1, 0), (0, l), and (1, 2). Outside the interval (- 2, 2), the interpolation kernel is zero. The damaged pixel is represented by pixel value zero. The value of this pixel can be obtained using the following equation.

$$s(x) = \sum_{k \in Z} c(k)\beta^n(x-k)$$

Where,
$\beta n(x)$ = central B - spline = basis (B) spline ; n= the no. of order

$$\beta^n(x) = \frac{1}{n!}\sum_{k=0}^{n+1}\binom{n+1}{k}(-1)^k\left(x-k+\frac{n+1}{2}\right)_+^n$$

2D equation for Cubic Hermite Spline:

$$f(x,y) = \sum_{k=k_1}^{(k_1+K-1)}\sum_{l=l_1}^{(l_1+K-1)} c(k,l)\beta^n(x-k)\beta^n(y-l)$$

V. APPLICATIONS

It can be used to restore the images with curved objects. It can be used to improve quality of the image of fingerprint, where the fingerprint is used to access, mainly in biometrics fingerprinting.

VI. CONCLUSION

In this paper we have described about Cubic hermit Spline interpolation for image restoration. Cubic Hermit Spline is useful in image zooming and interpolation which are perhaps the main applications. Analog-to- Digital conversion, contour detection, Geometric image transformation, Image compression, multi-scale image processing, image registration, filter design and fast continuous wavelet transformation are some of the other applications were Splines are helpful. Splines are well behaved functions as a result they have excellent approximation properties, precise convergence rates and less error rates. We conclude that Cubic Hermite Spline can be efficiently used for reconstructing the damaged curves in Image Inpainting.

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