



Reconstruction of Arteries in Heart Image Affected by Specular Reflection

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Abstract: This paper deal with efficient approach for reconstruction of arteries in heart image which is affected by disturbances such as specular reflections. Reconstruction schemes are sufficiently general for application in other fields, where disturbances in images should be eliminated ensuring continuity of local structures. Using histogram equalizing technique an efficient approach has been made for finding genuine specular reflected area in the heart image and filling those reflection affected area with the surrounding texture of heart surface. The continuity of the arteries in specular reflected area can be generated in image using interpolation technique. The smooth reconstruction of those areas can done by ensuring continuity of local structures using anisotropic diffusion and bilateral filtering.

Keywords: Specular Reflection.

I. INTRODUCTION

The specular reflection in a image act as noise for the source image. Consequently removal of the specular reflection is must to make our image data source noise free. Specular reflection presents create difficulties for many computer vision tasks, such as segmentation, detection and matching, since it captures source characteristics, creating a discontinuity in the omnipresent, object-determined diffuse part. For simplification, specularities are usually disregarded as outliers by methods that are based on the diffuse component analysis. Since the presence of specular reflection is inevitable in real world, and they do capture important scene information, e.g., surface shape and source characteristics, incorporation of specular regions in the analysis is important. The efficient approach has been made for reconstruction of original image structure in the presence of local disturbances such as specular reflections. During cardiac procedures (especially in minimally invasive interventions) finding the targeted vessel(s) is often complicated by accumulated adipose tissue on the external surface of the heart. Since the glossy surfaces give rise to specular reflection from light sources. There specular reflections of the point light source arise on the curved and deforming surface of the beating heart. Due to sudden and irregular occurrence these highlights disturb tracking of natural landmarks on the beating heart considerably. Reconstruction schemes are sufficiently general for application in other fields, where disturbances in images should be eliminated ensuring continuity of local structures. Without proper identification specularities are often mistaken for genuine surface markings by computer vision applications such as matching models to objects, deriving motion fields from optical flow or estimating depth from binocular stereo. Using histogram equalizing technique an efficient approach has been made for finding genuine area of specular reflection over the surface of the heart and filling those reflection affected area with the color of surrounding texture of heart surface [1].

II. METHOD

Specularities occur as highlights on the glossy heart surface. Since their grey values are distinctively high and independent of neighborhood intensities, simple thresholding can be applied for segmentation.

Structure inside specular areas is restored from local structure information determined by the well-known structure tensor. This yields reconstruction which is most likely to correspond to the original area on condition that surface structures possess some continuity as shown in Fig.1. Therefore intensity information mainly from boundary points along the current orientation is used.

It is not possible to develop and test in a clinical environment, thus all research activities were performed outside of the hospital. Therefore the image material used (angiographies and the live heart image sequences) were provided in digitized form by the Heart Center. The heart images are in a 720x576@24bit RGB format, while the angiograms are available as 512x512@8bit gray scale as shown in Fig.1.

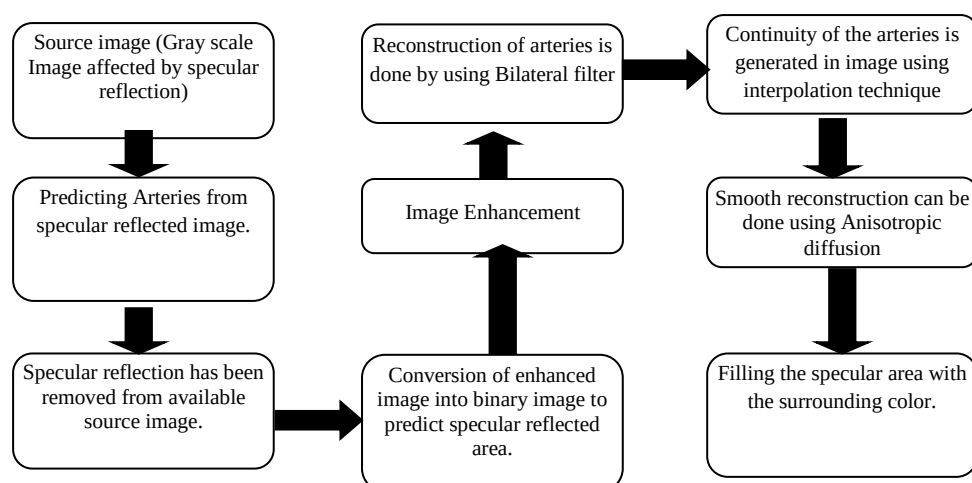


Fig. 1: Flow chart of the arteries reconstruction in heart image which is affected by specular reflection
Converting the image in RGB format to grayscale format (in Fig.2) is the best and convenient approach for any type of processing in the images.



Fig. 2: Specular reflected image of heart (source image)

A. Enhancing the image

Specular reflections occur as a result of light reflections on glossy surfaces, but due to their high intensity a thresholding operator is in most cases sufficient to localize them. Histogram analysis of the image and enhancing the contrast of images by transforming the values in an intensity of image, or the values in the color map of an indexed image, so that the histogram of the output image approximately matches a specific requirement for further processing of the images. The process of adjusting intensity values involves transforming the intensity values so that the histogram of the output image approximately matches a specified histogram. By using an adaptive equalizing technique the various intensity level of the image is enhanced and distinguished. An adaptive equalization performs contrast limited function of images. While histogram equalization works on the entire image, an adaptive equalization operates on small regions in the image, called tiles. Each tile's contrast is enhanced, so that the histogram of the output region approximately matches a specified histogram. After performing the equalization, adaptive histogram equation combines neighboring tiles using bilinear interpolation to eliminate artificially induced boundaries. To avoid amplifying any noise that might be present in the image and limit the contrast, especially in homogeneous areas of images. The above process in the images help to differentiate the various intensity levels of image to low and high level intensity and in this way the specular reflection is more specifically predicted from the image shown in Fig.3.



Fig. 3: Enhanced contrast image of heart

B. Filling the Specular Area

The boundary of the specular reflected area is determined by the above histogram analyzed image as shown in Fig. 4 which is the binary image of the Fig.3.

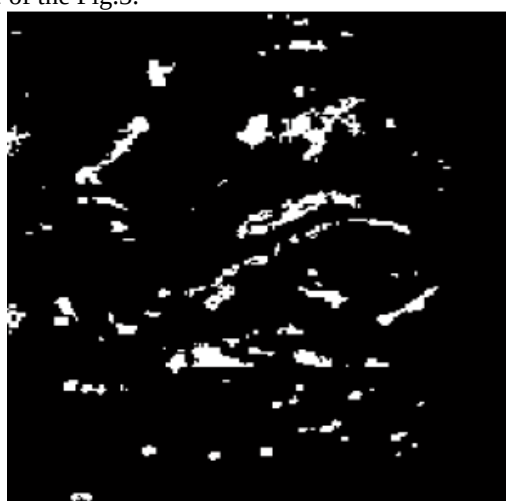


Fig. 4: Black & white image

This binary image is use for the determining the exact location and boundaries of specular reflection area in the image and the result of this process is to get the coordinates of the specular reflected area in images. Dilation of the binary images is shown in Fig.4. Since dilation process grows or thickens white portion of the binary images as shown in Fig.5.

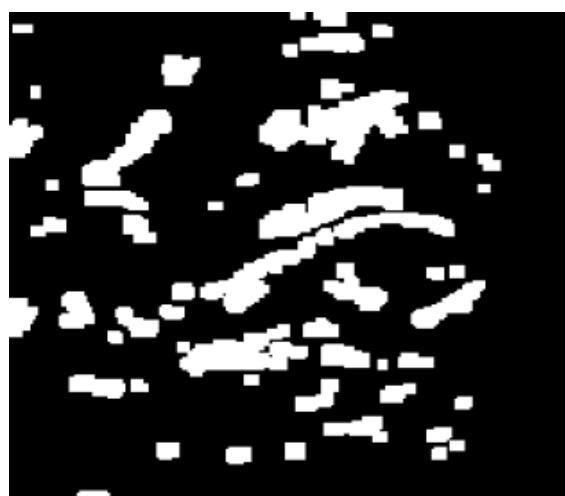


Fig. 5: Dilated imaging the Black & white image.

From this binary dilated image is used for finding the expanded boundaries of the binary image .The coordinates of the dilated image is used to fill those area with the color of the surrounding structure texture object in the source image. This dilated image is used as reference for finding the specular reflection area of the image and filling of those areas will be done in original source image [2] as shown in Fig.6.

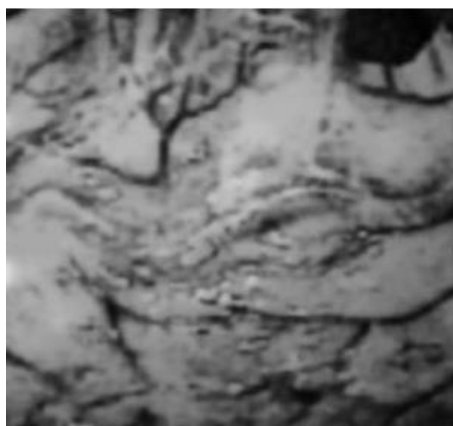


Fig. 6: Specular reflection in the original image is eliminated.

C. Image Reconstruction

The binary image of the above eliminated specular reflection image of heart is used to determine the edge of the arteries in the image. The edge of the arteries is determined by using sobel filter. To maintain the continuity of the arteries in specular reflected area can be generated in image using interpolation technique. The interpolation methods are often based on attempts to generate continuous data from a set of discrete data samples through an interpolation function. These methods attempt to improve the ultimate appearance of re-sampled images and minimise the visual defects arising from the inevitable resampling error [4]. The interpolation method helps to form continuity in arteries structure as shown in Fig.7.

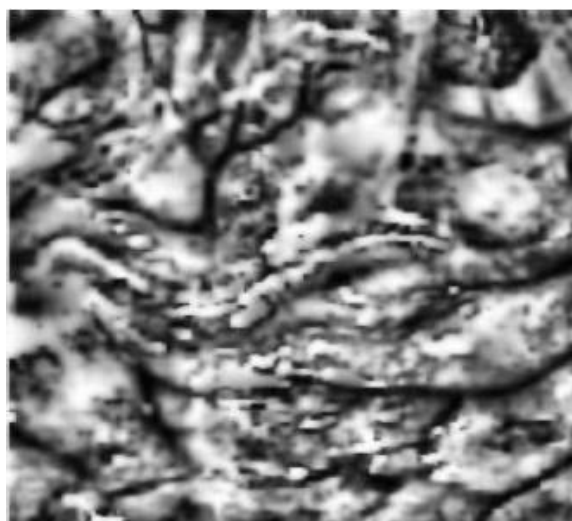


Fig. 7: Interpolation of image for determining the continuity of arteries.

Anisotropic Confidence-Based Filling-In: This reconstruction scheme fills specular areas from the boundary based on local structure information. It employs coherence enhancing anisotropic diffusion [5].

Coherence Enhancing Anisotropic Diffusion: Diffusion is generally conceived as a physical process that equilibrates concentration without creating or destroying mass. Applied to images, intensity at a certain location is identified with concentration. Thus the diffusion process implies smoothing of peaks and sharp changes of intensity, where the image gradient is strong. The discussed type of diffusion, designed to enhance the coherence of structures, is anisotropic and inhomogeneous. Inhomogeneous means that the strength of diffusion depends on the current image position, e.g. the absolute value of the gradient ∇f . Further, anisotropic diffusion corresponds to non-uniform smoothing, e.g. directed along structures. Thus edges can not only be preserved but even enhanced. The diffusion tensor

$D = D(J_\rho(\nabla f_\sigma))$, needed to specify anisotropy, has the same set of eigenvectors v_1, v_2 as the structure tensor J_ρ , reflecting local image structure. Its eigen values λ'_1, λ'_2 are chosen to enhance coherent structures, which implies a smoothing preference along the coherence direction v_2 with diffusivity λ'_2 increasing with respect to the coherence $(\lambda'_1 - \lambda'_2)^2$ of J_ρ :

$$\lambda'_1 \stackrel{\text{def}}{=} \alpha; \lambda'_2 \stackrel{\text{def}}{=} \begin{cases} \alpha & ; \text{if } \lambda_1 = \lambda_2 \\ \alpha + (1 - \alpha) \exp\left(\frac{-c}{\lambda_1 - \lambda_2^{2m}}\right) & ; \text{otherwise} \end{cases}$$

Where $c > 0$; $m \in \mathbb{N}$, $\alpha \in]0,1[$, and the exponential function ensures the smoothness of D . For homogeneous regions, α specifies the strength of diffusion. We follow with $C = 1$, $m = 1$ and $\alpha = 0.001$ [6].

The anisotropic filling-in scheme preserves structure occluded by specular reflections. Inherent smoothness of the diffusion process inside and at 4

the boundaries of specular reflections can be visually confirmed. Specularities can be eliminated if the iteration scheme is applied long enough, but not all intensity from large specular areas may be drained if time is restricted. The final image obtains which is free from specular reflection.

Bilateral filtering : This method removes highlights by iteratively shifting chromaticity values towards those of the neighboring pixel having the maximum chromaticity in the neighborhood. The neighborhood is determined using a “pseudo-coded” diffuse image which has exactly the same geometrical profile as the diffuse component of the input image and can be generated by shifting each pixel’s intensity and maximum chromaticity nonlinearly. the specular pixels to diffuse pixels for every surface color by projecting image colors along the illumination color direction to a point of lowest observed intensity. As a result, the decomposition can be expressed in a close form, and can be solved directly for every pixel. Their experimental results contained noise caused by a number of factors, including image noise, color blending at edges, and multiple surface colors. By integrating the texture from outside the highlight to determine the candidate diffuse color for traditional color space technique, that is for each pixel, a set of candidate diffuse colors is obtained from a texture scale of 1×1 , and is iteratively pruned as the texture scale increased [7]. The reconstructed image of arteries is shown in Fig.8.



Fig. 8: Reconstructed arteries in heart image.

III. RESULT

An efficient approach has been made to reconstruct the image which is affected by local disturbances such as specular reflection as shown in Fig.2. Histogram analysis is used for the enhancement of the image and predicting those specular areas from the enhanced image as shown in Fig.3. The formation of binary image help to predict the specular reflected area in image as hown in Fig.4 and dilated binary image is shown in Fig.5. Interpolation technique has been effectively used to maintain the continuity of the arteries in specular reflected area in image. Anisotropic filling-in creates inherently smooth areas; it applies a diffusion process depending on both orientation and strength of local structures. Anisotropic confidence-based filling-in employs smoothness constraints to reach an optimum solution for reconstruction. Bilateral filtering diffuses the low pixel intensity value to specular reflection area and integrating the texture from outside the highlight to maintaining the continuity of the arteries as shown in Fig.6. The reconstruction of arteries can be seen by outline the arteries edges as shown in Fig.9.

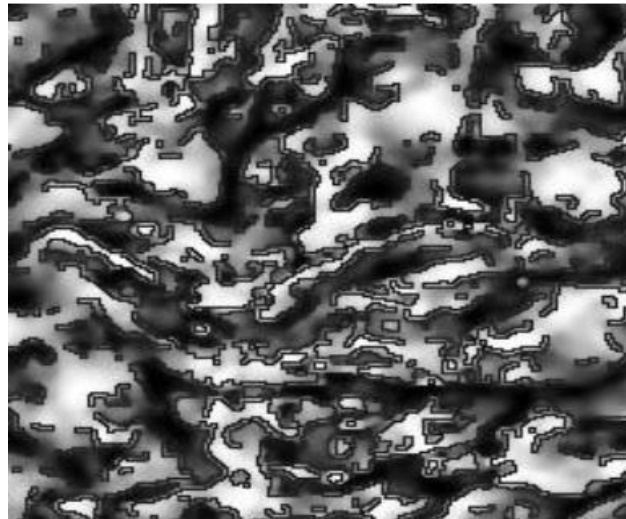


Fig. 9: Arteries is Outlined and also showing reconstructed portion of arteries.

IV. CONCLUSION

We presented in this paper an approach which facilitates the exact reconstruction of structure of the heart surface in the image which is affected by specular reflection. Histogram analysis is used for the enhancement of the image and predicting those specular areas from the enhanced image. Interpolation technique has been effectively used to maintain the continuity of the arteries in specular reflected area in image. Anisotropic filling-in creates inherently smooth areas; it applies a diffusion process depending on both orientation and strength of local structures. Anisotropic confidence-based filling-in employs smooth constraints to reach an optimum solution for reconstruction ensuring continuity of local structures of the heart surface. Bilateral filtering diffuses the low pixel intensity value to specular reflection area and maintaining the continuity of the arteries.

References

- [1] I. Nagy , A. Knoll , R. Bauernschmit , E. U. Schirmbeck and H. Mayer . *Real-time Matching of Angiographies with In Situ Heart Image Sequences*: Proceedings of the 17th IEEE Symposium on Computer-Based Medical Systems (CBMS'04)1063-7125/04 \$ 20.00 © 2004 IEEE. 5
- [2] Gonzalez and Woods : *Laboratory Projects for Digital Image Processing* : Prentice Hall Upper Saddle River, NJ 07458 USA © 2002
- [3] M. Greoger, W. Sepp, T. Ortmaier and G. Hirzinger: *Reconstruction of Image Structure in Presence of Specular Reflections*: B. Radig and S. Florczyk (Eds.): DAGM 2001,LNCS, pp. 53-60, 2001, Springer- Verlag Berlin Heidelberg 2001.
- [4] M. Gröger and G. Hirzinger, "Image Stabilisation of the Beating Heart by Local Linear Interpolation," in *Medical Imaging: Visualization, Image-Guided Procedures and Display* 2006.
- [5] A. Noce, J. Triboulet, and P. Poignet, "Efficient Tracking of the Heart Using Texture," in *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS 2007)*, (Lyon, France), pp. 4480–4483, Aug. 2007.
- [6] R. Richa, P. Poignet, and C. Liu, "Three-dimensional Motion Tracking for Beating Heart Surgery Using a Thin-plate Spline Deformable Model," *International Journal of Robotics Research*, vol. 20, pp. 218–230, Feb. 2010.
- [7] E. Bogatyrenko and U. D. Hanebeck, "Visual stabilization of a beating heart motion by model-based transformation of image sequences," in *Proceedings of the 2011 American Control Conference (ACC 2011)*, (San Francisco, California, USA), June 2011.
- [8] G. Kurz and U. D. Hanebeck, "Image Stabilization with Model-Based Tracking for Beating Heart Surgery," in *11. Jahrestagung der Deutschen Gesellschaft für Computer- und Roboterassistierte Chirurgie (CURAC12)*, Düsseldorf, Germany, 2012.
- [9] G. Kurz and U. D. Hanebeck, "2D and 3D Image Stabilization for Robotic Beating Heart Surgery," in *Proceedings of the 17th International Conference on Information Fusion (Fusion 2014)*, Salamanca, Spain, 2014.
- [10] G. Kurz, M. Baum and U. D. Hanebeck, "Real-time Kernel-based Multiple Target Tracking for Robotic Beating Heart Surgery," in *Proceedings of the Eighth IEEE Sensor Array and Multichannel Signal Processing Workshop (SAM 2014)*, A Coruna, Spain, 2014.