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Dynamic infrared thermography for DIEP flap breast reconstruction: initial processing results

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Abstract

In order to identify the exact location of the useful perforator for DIEP flap breast reconstruction, infrared images can be used. The thermal images will also help to determine which parts of the flap can be safely used for the DIEP flap reconstruction. By means of infrared thermography a blood vessel distribution of the abdominal wall will be visualized. The subjective interpretation of IR images is crucial as the results can generate additional information concerning the hemodynamic properties of the flap. One specific case will be used to explain the state-of-the-art post-processing methods.

1. Introduction

The main target of infrared (IR) thermographic assistance during DIEP flap breast reconstructive surgery is to map the dominant perforators and determine areas of the flap which will guarantee sufficient blood flow after transplantation. This will result in an increased success rate and reduction of partial necrosis. Dynamic Infrared Thermography (DIRT) is used to reveal the hemodynamic properties of the DIEP flap in order to assist in clinical assessment. The flap is stimulated with a cold challenge to obtain temperature difference between skin and the vessels. In case of perforator mapping, the first appearing hot spots will indicate the presence of a dominant perforator. In case of determination of well-perfused areas, the areas which are rapidly rewarmed indicate the presence of a strong developed vascular network of the particular perforator. The subjective interpretation of IR images is crucial as the results can generate additional information concerning the hemodynamic properties of the flap. At least the majority of papers which include thermographic assistance in medical application do not mention the use of post-processing techniques to enhance the resulting images [1,2]. The interpretation without post-processing enhancement is often known to be equivocal. One specific case will be used to explain the state-of-the-art post-processing methods.

2. Median Filter

Images are always polluted by noise during image acquisition and transmission, resulting in low-quality images. Thus, it is necessary to remove the noise before using the images for subsequent analysis tasks. A very common type of image noise is the so-called impulse noise. There are two types of this noise, which is salt and pepper noise and random valued noise. Median filtering is a nonlinear operation to reduce impulse noise. In salt and pepper noise the corrupted pixels take the maximum value or the minimum value which leads to white and black spots in the image. The Median Filter replaces the central value of an M-by-N neighbourhood with its median value. If the neighbourhood has a centre element, the filter places the median value there (Fig.1).

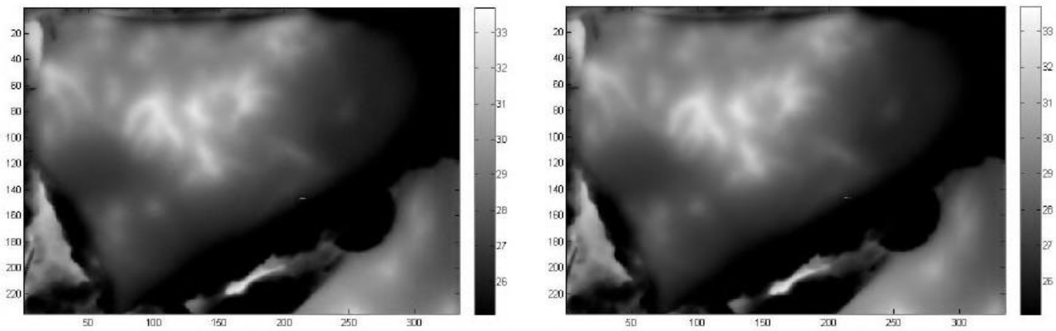

Fig. 1. *Results before and after applying a 3x3 Restricted Median Filter*

3. Gaussian Filter

Figure 2 shows the result for a Gaussian Filter with a variance equal to 5. As the variance increases, the result shows less detail. The areas of high blood perfusion are visualized with clearer boundaries. This filter will enhance the effectiveness of image segmentation in areas with high blood perfusion.

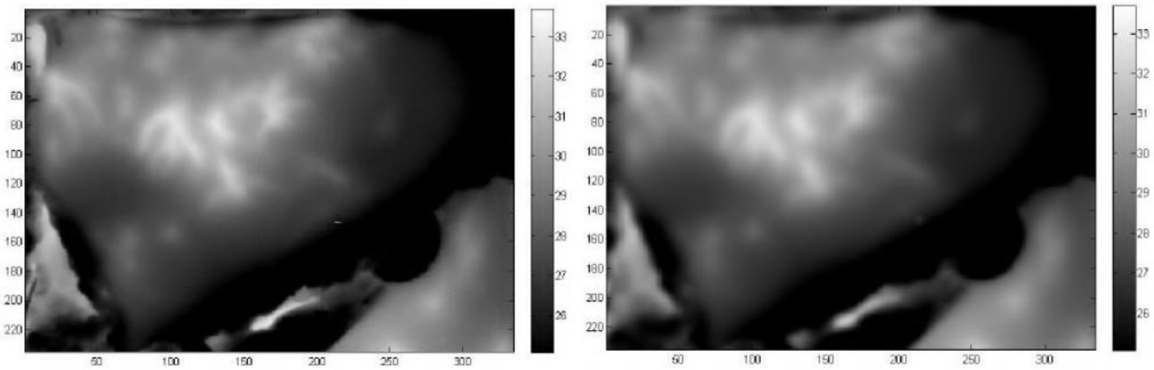

Fig. 2. *IR image before and after applying a Gaussian filter with variance equal to 5.*

3.1. PCT Method for Image Sequence

PCT is performed to the image sequence of rewarming a DIEP flap by natural perfusion. Figure 3 shows the images of the first 3 principal components of the image sequence. The first 3 components can be used in further image enhancement because the images contain 56.3% of variance. The higher principal components are not valuable for the interpretation as they contain 0 to 1.2% of variance. The removal of all image noise results in less variance in the data matrices.

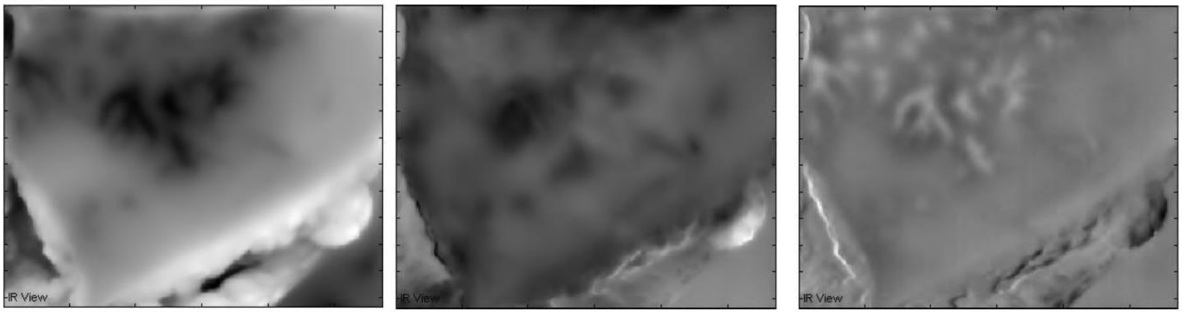

Fig. 3. *First 3 principal component images generated with PCT.*

4. Conclusion

The most valuable post-processing technique is obtained by combining all mentioned techniques. The resulting technique differs according to the application. both perforator mapping and the determination of well-perfused areas call for a different approach to optimize the visualization. PCT is a valuable technique because it generates a few images based on the analysis of the complete image sequence.

REFERENCES

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