

Information Fusion and Wavelet Based Segment Detection with Applications to the Identification of 3D Target T-ray CT Imaging

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Abstract—In this paper, segmentation techniques depending on T-ray CT functional imaging [1] are investigated. A set of linear image fusion and novel wavelet scale correlation segmentation techniques are adopted in order to achieve classification within 3D objects. The methods are applied to a T-ray CT image dataset of a glass vial containing a plastic tube. This experiment simulates the imaging of a simple nested organic structure, which will provide an indication of the potential for using T-ray CT imaging to achieve T-ray pulsed signal classification of heterogeneous layers.

I. THE METHODOLOGY

In principle, T-ray computed tomography (CT) extracts the frequency dependent 3D characteristics of a target sample [1]. This makes possible rich four-dimensional datasets that describe the sample. To achieve the final T-ray CT image, an Inverse Radon Transform (IRT) is computed on the Fourier coefficients of the measured signals. To achieve 3D T-ray CT classification, image fusion methods and segmentation techniques are applied to extract three different target segments and to realise target recognition. The image fusion can be achieved via merging two or more registered images.

This experiment utilizes a phantom with an internal structure consisting of a plastic tube inserted inside a glass vial is imaged. Since the glass is relatively transparent to T-rays, the internal plastic tube is visible. The phantom is imaged at vial heights from 5mm to 9 mm (from the bottom), in 1mm increments. A linear combination of the related weighted slice images is computed for image fusion. Due to SNR limitations in the experimental apparatus, at high frequencies, only the images of the current phantom corresponding to the ten lowest frequencies are selected. The weights in the linear combination are selected based on the SNR values at the various frequencies. In this work, the weight is 1/6 for the five lowest frequency images and 2/6 for the five higher frequency images. The resultant fused image is found to have clear target contours and show greater contrast between the target regions and the background.

Segment detection achieves differentiated subdivision of constituent regions of an image. The usual methods focus on enhancing the target of interest while ignoring the irrelevant image details [2]. In this paper, a novel 2D wavelet scale correlation method is used to extract target segments from the background. This method is motivated by one dimensional wavelet scale correlation denoising. Firstly, the target cross-sections are assumed to be corrupted by additive white Gaussian noise, which is distributed randomly. The

target objects are separated by their absorption parameter, which are indicated by the intensity of the images. With the incremental wavelet scale, the noise is reduced and the target intensity (energy) is increased in an image. After computing 2D DWTs [3] of fused T-ray CT images, the portions for the increased energy can be viewed as the target segments. Therefore, an increased energy with an increase in wavelet scale is used as a cue to extract the target regions. The wavelet scale correlation based segmentation algorithm is:

1. Calculate 2D DWT at first and second scales.

2. Compute the correlation $R_{1,2}(m,n)$ for the two scales:

$$R_{1,2}(m,n) = s_1(m,n) \times s_2(m,n) \quad (1)$$

where $s_i(m,n)$ denotes the approximation coefficient at coordinates (m,n) of i -th 2D DWT of the image.

3. The energy of $R_{1,2}(m,n)$ and $s_1(m,n)$ is computed:

$$E_{s1} = \sum s_1^2(m,n) \quad (2)$$

$$E_{R12} = \sum R_{12}^2(m,n) \quad (3)$$

It is necessary to normalise the coefficients for comparison between the wavelet and correlation coefficients:

$$R_{1,2}^*(m,n) = R_{1,2}(m,n) (E_{s1}/E_{R12})^{1/2} \quad (4)$$

4. The correlation and wavelet coefficients $|R_{1,2}^*(m,n)|$ and $|s_1(m,n)|$ are compared. If $|R_{1,2}^*(m,n)| > |s_1(m,n)|$, the corresponding pixel is extracted as part of a target segment, otherwise they are regarded as background and set to 0.

The Canny edge detector is used to perform the final subtraction of each target function edge [3] in the T-ray CT image. Using varieties in intensity, the Canny detector enables the extraction of the tube edges and hence separates out the different segments of the vial and the tube. The segments are required to classify each pixel as either glass vial, plastic tube or the background.

II. CONCLUSION

This paper investigates the application of wavelet based segmentation techniques following image fusion. This paper is an important exploration for automatic T-ray CT target identification within 3D heterogeneous materials.

REFERENCES

- [1] B. Ferguson, S.H. Wang, D. Gray, D. Abbott, and X-C Zhang, "Towards functional 3D T-ray imaging", *Physics in Medicine and Biology*, vol. 47, pp. 3725-3742, 2002.
- [2] R. C. Gonzalez and R. E. Woods. *Digital Image Processing*, Prentice-Hall, Inc., New Jersey, 2002.
- [3] S. G. Mallat. *A Wavelet tour of Signal Processing*, San Diego: Academic Press, CA, 1999.