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An Improved Discrete Tomography Algorithm for Reconstructing Images with Multiple Gray Levels

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ABSTRACT: The discrete algebraic reconstruction technique has many advantages in computed tomography and electron tomography. However, the number of gray levels and the absolute gray values that should be known in advance are typically not available in experiments especially when there are manygray levels in the image. In this paper, we report an automatic discrete tomography reconstruction algorithm to improve its feasibility in practice, without needing to know these two parameters. In our algorithm, the number of gray levels is estimated by labeling the connected components in the tomogram and the absolute values of them are determined by the modal value of each domain. The proposed algorithm was extensively validated on both simulated and experimental datasets. The results show that our algorithm can accurately recover not only the morphology but also the gray levels of the interested objects, even in the images with multiple gray levels. It is demonstrated that the presented algorithm is robust for eliminating missing wedge artifacts and tolerable for noisy data.

KEYWORDS: ACCORDION, DCT, QUNATIZATION, ZIGZAG, RLE, TEMPORAL AND SPATIAL REDUNDANCY.

I. INTRODUCTION

X-ray test is a very common, non-invasive radiology test that produces an image of the chest and the internal organs. To produce a chest X-ray test, the chest is briefly exposed to radiation from an X-ray machine and an image is produced on a film or into a digital computer. Chest X-ray is alsoreferred to as a chest radiograph, chest roentgenogram, or CXR. Depending on its density, each organ within the chest cavity absorbs varying degrees of radiation, producing different shadows on the film.Chest X-ray images are black and white with only the brightness or darkness defining the various structures. For example, bones of the chest wall (ribs and vertebrae) may absorb more of the radiationand thus, appear whiter on the film.

Here we propose two different techniques of Histogram Equalization namely, the global HE and local HE. The Histogram Equalization has been performed in the MATLAB environment. The merits and demerits of both techniques of Histogram Equalization have also been discussed. It is seen after exhaustive experimentation on a number of sample images that the proposed image enhancement techniques can be considered as an improvement over the inbuilt MATLAB function histeq. Enhancement is a very subjective area of image processing. Image enhancement can be carried out in two domains-spatial domain and frequency domain. Histogram and its equalization is a spatial domain or pixel domain processing where as in some manipulation is carried out in the image pixels in order to have enhanced image.

II. LITERATURE SURVEY

R. H. Shen et al. [1] The missing wedge effect in electron tomography introduces various types of artifacts in the tomograms and lowers the reconstruction resolution and quality. The artifacts produced in tomographic reconstruction of bulk materials can be very severe, particularly for sinteredbulk ceramic materials in which there are often nano-pores or pore-like microstructure features. Here, we report a neural network algebraic reconstruction algorithm with no prior knowledge to perform electron tomography for a sintered Si C material with nano carbon zones.

X. W. Yu et al. [2] Pre-deformation before aging has been demonstrated to have a positive effect on the mechanical strength of the 7N01 alloy in our previous study, which is rather different from the general negative effects of pre-deformation on high-strength 7XXX aluminum alloys. In order to explain the strengthening mechanism relating to the positive effect, in the present study, themicrostructure of the aged 7N01 alloy with different degrees of pre-deformation was investigated in detail using advanced electron microscopy techniques. Our results show that, without pre-deformation, the aged alloy is strengthened mainly by the η' type of hardening precipitates.

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J. H. Liu et al [3] Full angular rotational projections cannot always be acquired in tomographic reconstructions because of the limited space in the experimental setup, leading to the `missing wedge' situation. In this paper, a recovering `missing wedge' discrete algebraic reconstruction technique algorithm (rmw DART) has been proposed to solve the `missing wedge' problem and improve the quality of the three-dimensional reconstruction without prior knowledge of the material component'snumber or the material's values.
X. D. Zhuge et al.[4] Electron tomography is an essential imaging technique for the investigation of morphology and 3D structure of nanomaterials. This method, however, suffers from well-known missing wedge artifacts due to a restricted tilt range, which limits the objectiveness, repeatability and efficiency of quantitative structural analysis. Discrete tomography represents one ofthe promising reconstruction techniques for materials science, potentially capable of delivering higher fidelity reconstructions by exploiting the prior knowledge of the limited number of material compositions in a specimen.

X. Zhuge et al. [5] In this paper, they are present a novel iterative reconstruction algorithm for discrete tomography (DT) named total variation regularized discrete algebraic reconstruction technique (TVR-DART) with automated gray value estimation. This algorithm is more robust and automated than the original DART algorithm, and is aimed at imaging of objects consisting of only a few different material compositions, each corresponding to a different gray value in the reconstruction. Furthermore, the new algorithm requires less effort on parameter tuning compared with the original DART algorithm.
With TVR-DART, there aim to provide the tomography society with an easy-to-use and robust algorithm for DT. A. Kupsch et al. [6] These artefacts appear as elongations of reconstructed details along the mean direction (i.e. the symmetry centre of the projections). Although absent in standard computed tomography applications, they are most prominent in advanced electron tomography and also in special topics of X-ray and neutron tomography under restricted geometric boundary conditions. We investigate the performance of the DIRECTT (Direct Iterative Reconstruction of Computed Tomography Trajectories) algorithm to reduce the directional artefacts in standard procedures.

X. B. Yang et al. [7] An Al–7.60Zn–2.55Mg (wt.%) alloy with a characteristically high Mg-to-Zn atomic ratio has been investigated for its strength and hardening precipitates in comparison with that of 7150 alloy. It is shown that this alloy yields a rather high strength upon thermal ageing. Interesting is that this high- strength alloy is hardened by the coherent polyhedral T-phase [(AlZn)49Mg32] particles and their early-stage precipitates, which is very different from that of otherhigh-strength AA7 xxx.
S. K. Malladi et al. [8] they are present a new approach to study the three-dimensional compositional and structural evolution of metal alloys during heat treatments such as commonly used for improving overall material properties. It relies on in situ heating in a high-resolution scanning transmission electron microscope (STEM). The approach is demonstrated using a commercial Al alloy AA2024 at 100–240 °C, showing in unparalleled detail where and how precipitates nucleate, grow, or dissolve. The observed size evolution of individual precipitates enables a separation betweennucleation and growth phenomena, necessary for the development of refined growth models.
W. Van den Broek et al.[9] In materials science, high angle annular dark field scanning transmission electron microscopy is often used for tomography at the nanometer scale. In this work, it is shown that a thickness dependent, non-linear damping of the recorded intensities occurs. This results in an underestimated intensity in the interior of reconstructions of homogeneousparticles, which is known as the cupping artifact. In this paper, this non-linear effect is demonstratedin experimental images taken under common conditions and is reproduced with a numerical simulation. Furthermore, an analytical derivation shows that these non-linearities can be inverted if the imaging is done quantitatively, thus preventing cupping in the reconstruction.
Sitti Rach mawati Yahya1 et al. [10] Canadian National Railway (CN) operates main line tracksthat traverse mountainous terrain and are exposed to rockfall hazards. Between 1995 and 1997, CN, in collaboration with BGC Engineering Inc. and Oboni Associates Inc. (BGC, OA), developed and implemented a rockfall hazard risk assessment rating system (CN RHRA rating). The development and implementation of this rating methodology on mainline track in Western Canada is documentedin two previous papers (1, 2). This paper provides an update to the previous papers with a review of the methodology and use of the rating system, and a discussion of additional modifications and enhancements to the rating system since implementation.

III. PROPOSED METHOD

The new algorithm requires less effort on parameter tuning compared with the original DART algorithm. With DART, we aim to provide the tomography society with a easy-to-use and robust algorithm for DT. Electron tomography data sets show that DART is capable of providing more accurate reconstruction. The proposed IDART algorithm follows the basic idea of the original DARTthat the gray values of pixels in boundary and non-boundary regions can be updated by

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continuous and discrete reconstruction methods, respectively. Therefore, the flowchart of IDART is similar withDART. However, the thresholds that distinguish different gray levels in DART, TVR-DART, PDM-DART and MDART are replaced by separated connected components which can be searched automatically by segmentation algorithms. Therefore, in IDART, there is no need to input the threshold vector or to estimate it during reconstruction. Meanwhile, the modal value of each connected domain will automatically be assigned to all non-boundary pixels in each domain after inner iterations (SIRT in the present study), thus making the gray values of all connected componentsdiscrete. Other advantage of introducing connected components is that we do not have to know the number of gray levels in advance, as compared with TVR-DART and PDM-DART. This is important, especially when there exist a large number of gray levels in the image to be reconstructed. The procedure of IDART. After a SIRT reconstruction, segmentation of the reconstructed tomogramis performed using the Otsu method. To obtain a better performance, a weighting factor (WF) is divided by the Otsu threshold to adjust the segmentation in this step. Applying a small threshold (big WF), we can keep more details in the segmented tomogram.

BLOCK DIAGRAM:

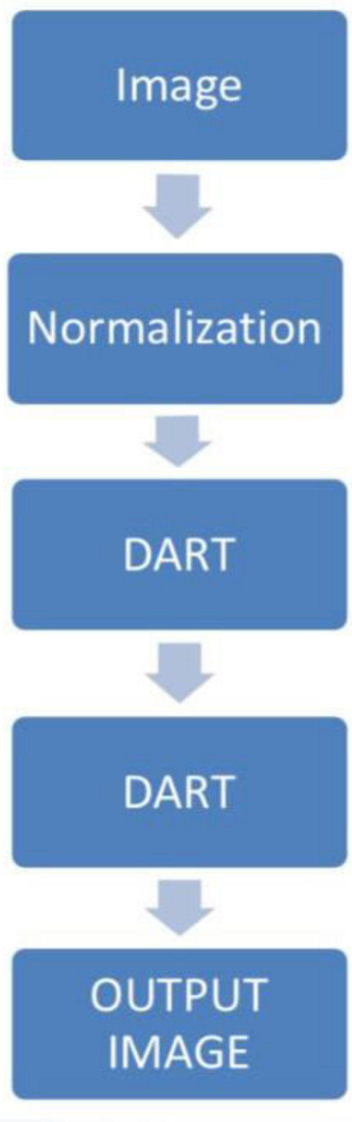

FIG 1: BLOCK DIAGRAM (PROPOSED METHOD)

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THE PROCESS:

- Histogram equalization is a widely used contrast-enhancement technique in image processing because its high efficiency and simplicity. It is one of the sophisticated methods for modifyingthe dynamic range and contrast of an image by altering that image such that its intensity histogram has the desired shape.
- Is an additive color model in which the red, green and blue primary colors of light are addedtogether in various ways to reproduce a broad array of colors. The name of the model comesfrom the initials of the three additive primary colors, red, green, and blue.
- Is a process that is used to obtain high-quality digital radiographic images in terms ofmaximizing important details or suppressing unwanted details in the image.
- Normalization is a process that changes the range of pixel intensity values. Applications includephotographs with poor contrast due to glare, for example. Normalization is sometimes called contrast stretching or histogram stretching.
- Pre-processing is an improvement of the image data that suppresses unwilling distortions or enhances some image features important for further processing, although geometric transformations of images (e.g. rotation, scaling, translation) are classified among pre-processmethods.

IV. RESULTS

This section verifies the performance of the proposed DART model. Here Figure.5.1 shows the Original image. Figure.5.2 shows the Original image Histogram.Figure.6 and Figure.5.3 shows the Image histogram output. Figure.5.4 shows the Image Processing. Figure.5.5 shows the Global Thresholding. Figure.5.6 shows the Mult Level Segmentation n=2. Figure.5.7 shows the DART Image.Figure.5.8 shows the Output Image.

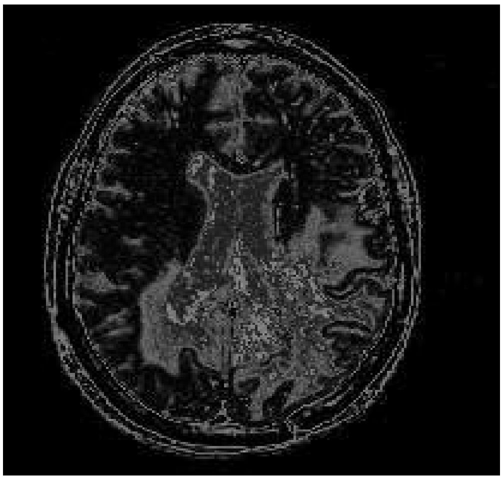

Fig 5.1: Original image

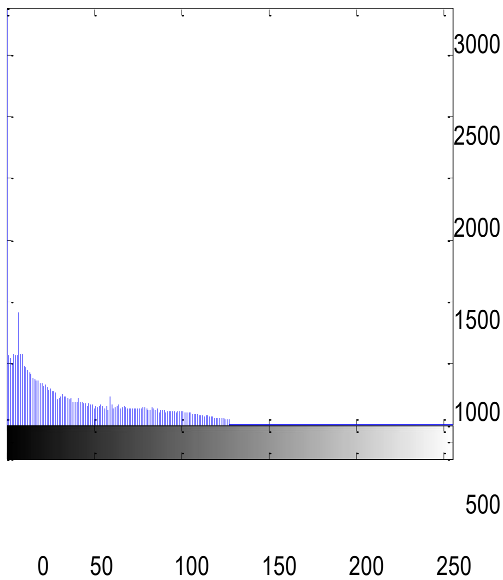

Fig 5.2: Original image Histogram

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Fig 5.3: Image histogram output

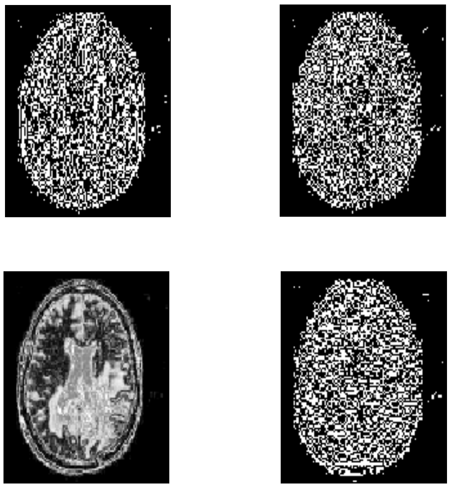

Fig 5.4: Image Processing

Fig 5.5: Global Thresholding

Fig 5.6 : Multi Level Segmentation n=2

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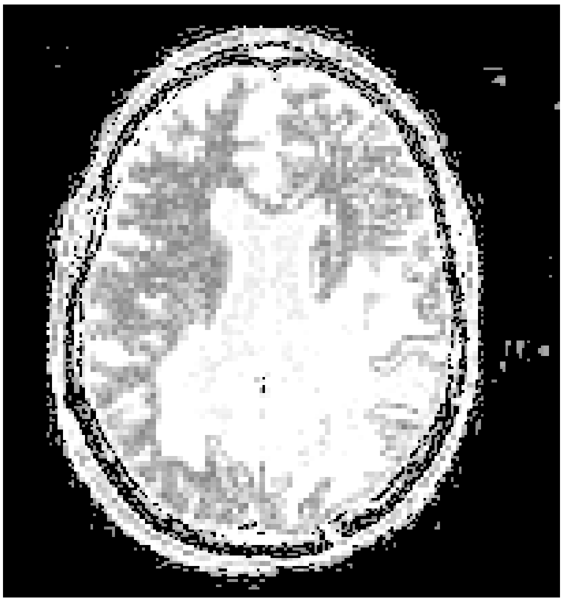

Fig 5.7: DART Image

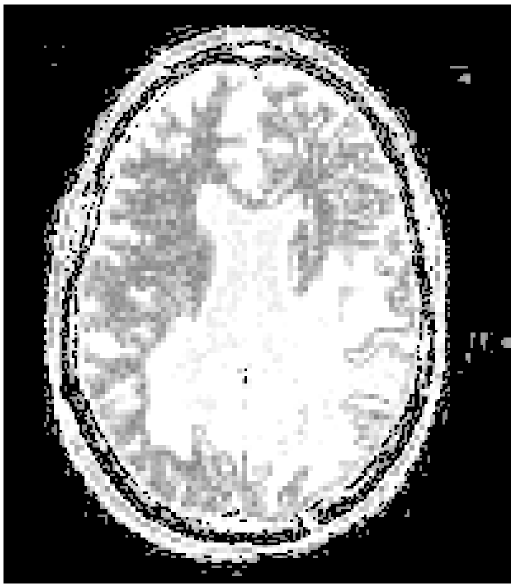

Fig 5.8: Output Image

IV. CONCLUSION

The present study proposes an improved discrete algebraic reconstruction technique, IDART, aiming to develop a robu stand accurate method for reconstructing the material samples containing multi-composition particles, corresponding to the multiple gray levels in the targeted objects or in their cross-sectional reconstruction (tomogram) images. The IDART can automatically estimate the absolute gray values, as well as the number of gray levels contained in the objects to be reconstructed.It neglects the threshold vector used to assign gray values in conventional DART based methods. These can be realized based on the fact that the intensity (gray level) across an independent object inthe reconstructed image should be even or constant. In this way, the reconstructed tomogram can be divided into several connected components whose gray values can be estimated as the modal value of a local domain. This procedure overcomes the bottleneck of other DART based methods in accuracy and feasibility in the cases where there exist more than five gray levels in the image to be reconstructed. We tested the performance of IDART algorithm using several simulated phantoms. We also verified its validity using experimental TEM images of Au-Ag core shell nanorods. The results show that IDART can recover both the morphology and the gray levels of the objects accurately using only limited projection datasets.

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