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Minimization of Streak Artifacts in CT Images Using Particle swarm optimization based Algorithm

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Abstract: *In computed tomography (CT) images, metal inculcates raises the deviations between the consistent data and the linear attenuation inference maintained by perceptive CT reconstruction algorithms. The deviations create the increase of bright and dark bands and streaks in the ultimate reconstructed image, untidily known as metal artifacts. The artifacts in the CT image become difficult for radiologists to acquire actual diagnostic arbitration[1]. The Numerous probable causes of metal streak artifacts are designed using phantom simulations and measurements. Beam hardening, exponential edge-gradient effect, scattering effect, noise are analyzed as potential causes of metal streak artifacts[2].PSO (particle swarm optimization) the algorithm uses a back projection method called as particle based back projection for projection data particles in the optimized space during back-projection relatively to the location where each angle is resided at the time of projection. Better results are acquired for simulations and phantom measurements streak artifacts are minimized throughout the time and the slight line-shaped particulars are preserved. Noise can be minimized using iterative reconstruction or by combining data from different scans. This enables lower radiation dose and higher resolution scans. Streak artifacts are reduced using iterative reconstruction, proceeding in extended accurate diagnosis.*

Keywords: *Computed tomography, reconstruction, streak artifacts, PSO*

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I. Introduction

Artifacts can reduce the quality of image which affects the clarity of the every particular detail. An artifact is an error or interruption in an image which is not related to the entire medical image. CT artifacts initiated from several sources inclusive of patient. Streak artifacts are generated by miscellaneous mechanisms like motion, beam hardening, Poisson ratio, edge effects, and scatter. Streak artifacts are minimized by iterative reconstruction. X-ray computed tomography (CT) is a dominant cross sectional imaging technique collaborated with high image resolution and acquisition speed. From a decade many researchers have demonstrated how to remove metal streak artifacts using numerous approaches that are based on the assumption that measured data affected by metal objects are not used for reconstruction. Streaking, this is mainly due to an inconsistency in a single measurement[5]. At recent times proposed iterative algorithms works to reduce beam hardening effects without any knowledge prior by disintegrating the image to be reconstructed into low and high density components [14, 15].

A wide variety of techniques have been proposed, a priority vendors generally offer several implementations of iterative reconstructions algorithms by using their systems. The essential concept is to treasure the most feasible image given the projection data, the relationship between the image and the projection and the ahead distribution of images. This optimization issue is too complex to determine analytically, so resolved iteratively with data. The presence of noise in the projection data, there is a wide range of different images that are consistent with the measured projection data. The prior distribution of images prepares the iterative reconstruction to utilize a smooth perfect image among of the variety of attainable images. In the X-ray beam gets hardened while passing through the material, the energy spectrum is shifted toward the higher energies. So the basic problem arises during the CT scanning for patients having metallic transplantations, which leads to dramatic increment of attenuation properties for all the lower energies. The high attenuation coefficients of metal objects exceptionally reduce the photon signals. This degrades the signal-to-noise ratio (SNR) and the disturbances in a sinogram create streak artifacts in the reconstructed CT image. Although, beam hardening results are becoming worse as a ray passing along the higher density objects in extended path because of a polychromatic X-ray source. Those artifacts occult details regarding formalistic structures, changes the image into noisy images which becomes difficult for radiologists for apt diagnosis. A simulation is used to the effectiveness of the artifact reduction[11]. Some procedures for minimizing the noise and out of field artifacts can provoke the ultra high resolution restricted to a particular view of imaging of tumors and different structures. In this paper our speculation is that the streak artifacts consequences from variations between the actual acquisition method and the analytical model predicted by the reconstruction algorithm. , So enhancing the throughput of the model must degrade or eliminate the total artifacts. If through some projection lines all photons got attenuated making the projections incomplete. Hence in this paper we include the prior knowledge that make up for the missing information.

This paper presents a new algorithm for streak artifact reduction using PSO based pixel specific back projection .Further, we show the results of applying this algorithm to simulations and noise reduction.

II. Proposed method

Particle swarm optimization is one of the evolutionary estimation which is exhilarated by social behavior of bird flocking. Then PSO has evolved much wider aspects and became an interesting, trending research subject called as swarm intelligence.PSO has been applied to numerous optimizations, designing and exploring applications. There is different number of PSO variants in the optimization space. Many hybrid algorithms have developed by adding PSO with the many existing algorithms[8]. PSO searches the total space of relative function by changing the orientation of individual factors, known as particles. In tomographic methods, projections are collected from numerous different angles within the body through one or more rotating detectors.

Filtering can also be considered as a post processing step in iterative reconstruction. Though

many times iteratively reconstructed images need to be filtered afterwards, as they tend to be noisy, special dedicated iterative filters are not estimated still to be incorporated in trading software. In this paper we proposed a selection of filters for some CT examinations that are familiar in clinical diagnosis which are recommended in the literature. In computerized tomography the 2D function of a digitized image (pixel unit) is reconstructed at different angles using a set of its 1D projection. PSO is heuristic technique that takes extra time to implement optimal threshold value and which don't have the accurate threshold due to the consideration of the best parameters. So to avoid the drawbacks, a innovative image reconstruction procedure is proposed in this paper.

In this paper, we have proposed an pixel specific back projection based on PSO for image to reconstruct high quality medical images which are influenced by disturbances with different variances[10]. The PSO method was used to search near-optimal thresholds by minimizing the cross entropy between the original image and its threshold version. Maitra et al. (2008) proposed a new thresholding algorithm for histogram based image segmentation using a hybrid cooperative-comprehensive learning based on the PSO algorithm. Here the present system uses the PSO for the back projection. In back projection method, the sinogram is determined by the Radon transform. Once the transformation is done, the sinogram can be utilized for the back projection.In the mean while the projection of the particles is initialized. Those particles are treated as parallel particles by which the positions are estimated for the particles to project in the space. The particles are changed as the parallel particles based on the movement along the path as initialized. The rotator paths specify the particles movement in different directions with the angle as thetas. The particle movements are then noted and maintained same as initial values. This proposed method uses number of particles to create a set of vectors and move around the space to search best probable solution. The particle included in the group to search for its own parameters and parameters of other particles also. The ultimate solution can be achieved by a particle is also referred as pbest and another best value estimated by neighborhood of the particle is referred as gbest. The Iterative procedure is pursued in each and every step with random weight age factors to search for pbest and gbest values for each particle. The below figure shows the concept behind the particle swarm optimization pi is current position and pi+1 is renovated with position of a particles in the swarm space, and vpbest and vgbest are the final values updated by particle and best value estimated by its neighbor relatively.

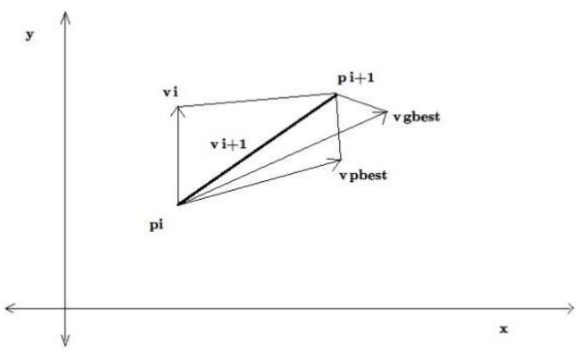

Fig: concept of searching point in a space

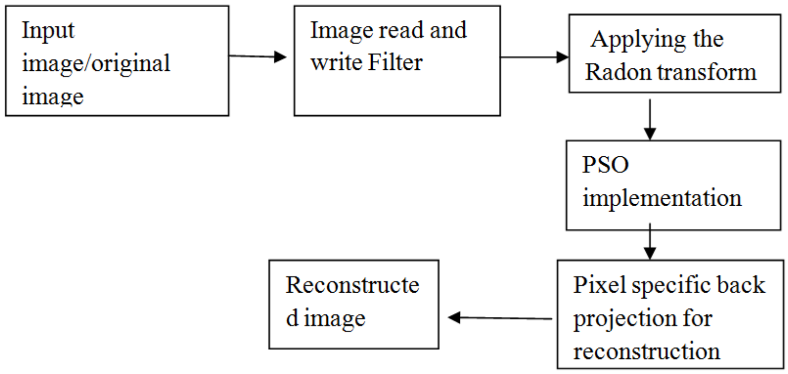

Fig : steps in the reconstruction process for reducing the streak artifacts

The Particle based back projection algorithm reduces streak artifacts by carrying out the back-projection in a frame of reference which is moving along the particle optimized path . The motion at the time of scanning is designed as a magnification and shift along particular origin point. The Particle based back projection utilizes projection data of the particles during back-projection that corresponds to the location at which each angle resided at the time each projection was measured. The particle moves around the swarm in different directions that are given by the angle or thetas of rotation. The path is estimated with the help of the parallel path of the projecting particles that are specified based on the mid index position of the optimized path along the particles and the projection of all the particles. PSO is initialized with a set of random particles[8]. This algorithm searches for optima along a series of iterations in the reconstruction. The fitness value of the random particles is evaluated in each iteration. If the best value of the particle is specified, the particle records the location of the value pbest (particle best). The position of the best fitness value can be estimated by any random particle at random iteration is recorded as gbest (global best) [8].

The position and the velocity of the particles are randomly set within lower and upper boundaries During each iteration velocity of a particle is updated using following mathematical equation[ ]

$$vi=wvi+c2R2\ (pi,est-pi\ )+c2R2\ (gi,best-pi\ )$$

Where pi is position of the ith particle, and vi is velocity of ith particle. $pi,est$is the best predicted value achieved by the ith particle and $gi,best$ is the best value found by the total swarm. then after getting the changed velocities the new location of the particle is estimated between two successive iterations using the equation

$$p1=pi+vit$$

Where t is time between two consecutive iterations. Again getting new location the countercheck is implemented to check if value is in approved upper and lower boundaries. The values of pi,est and $gi,best$ are changed as conditional statements[8]

$$pi,best=pi\ if\ f\ (pi>f)\ pi,best$$
$$gi,best=gi\ if\ f\ (gi>f)\ gi,best$$

Iterative process is pursued to repeat this algorithm until it reaches to a termination. Once it's terminated the values of gi,est and $f(gi,best)$ are recorded as final values.

The multiple projections can be considered into account by performing radon transform on the data, and filtered back projection is used for reconstruction. These can be implemented using the mathematical equation

$$x(\ z)\ ,y\ (z\ )=(zsin\alpha+scos\alpha,-zcos\alpha+ssin\alpha)$$

Radon space based on the local statistical parameters of the CT projections. Primarily we design the noise characteristics of a projection sample experiencing important preprocessing steps. The algorithm designed such that its factors are dynamically changed to evolve in the local noise characteristics. The main advantage of prior information about the metal in the CT image that is made constant in the domain containing metal. That particular information is considered in order to correct and can reduce the discrepancy among the Radon transform of the metal image and its projection data.

III. Results and discussion

Simulations shows pixel based back projection reconstruction of the computed tomography brain image. In this paper, we have proposed an innovative image reconstruction method based on PSO. The particle based back projection image is observed and the streak artifacts are minimized by these particles after the projection of the particles movement. The CT brain image with streak artifacts is taken as input image and implementing the proposed method the output image is observed with reduced streak artifacts which is clearly shown in the below images. The image having the highest number of edge pixels can be specified as perfect detail contents as shown below

Fig : Input brain image

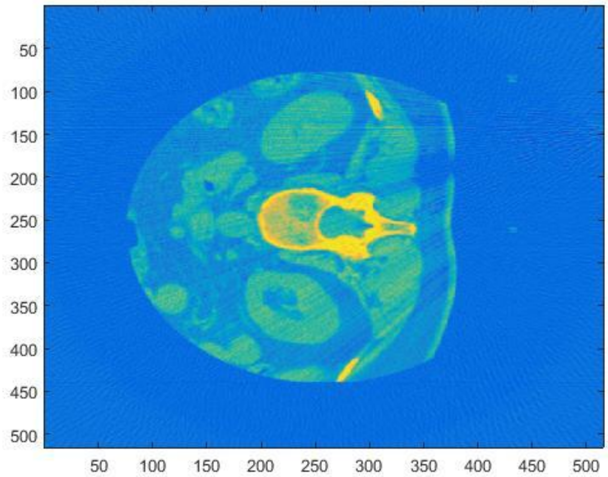

Fig: reconstructed image with minimized streaks

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