A Method Based on Particle Swarm Optimization for Finding Optimum Opacity Transfer Function

Ç. KILIKÇIER[1] and E.YILMAZ[1]

[1] Bursa Uludag University, Bursa/Turkey, caglark@uludag.edu.tr
[1] Bursa Uludag University, Bursa/Turkey, ersen@uludag.edu.tr

Abstract **- Automatic opacity determination of the voxels in a 3D image is important for getting the right interpretation of the image. In this study, we propose a method based on Particle Swarm Optimization (PSO) algorithm which can be used for finding the opacity values of opacity transfer function. The method requires information about region of interest (ROI) in the image. The performance of the proposed method is analyzed on the phantom images having nested spheres and the results is presented visually.**

Keywords **– PSO, Transfer function, opacity, optimization.**

I. Introduction

Finding a transfer function (TF) is an important step in visualization of the volumetric data. There have been proposed different methods to visualize the data, such as maximum intensity projection, local maximum projection, and ray-casting [1]. Seeing inside the volumes in a transparent manner can be realized by using an opacity transfer function. This function is used for revealing the distinguishing features of images viewed [2]. TF is essential in visualization of 3D medical volume data and large scale microscopy imaging [3].

TFs can be 1D or multi dimensional depending on the task. The design of multidimensional TFs is more complex than one dimensional TFs function. Visual properties like color and opacity values are mapped to the volumes in the transfer functions [4].

There are several ways to create a TF, interactively, automatically or semi-automatically. In this study, we propose a semi-automatic method based on PSO for generating opacity values of the opacity transfer function.

II. Particle Swarm Optimization (PSO)

PSO is proposed in [5] by Kennedy and Eberhart. It is based on swarm intelligence methodology. Initially, a swarm of particles is randomly chosen in the solution space. Then, the particles (position λ and velocity V) are updated iteratively by using (1) and (2).

$$V_i^{k+1} = \omega V_i^k + c_1 r_1^k \left(P_i^k - \lambda_i^k\right) + c_2 r_2^k \left(G^k - \lambda_i^k\right) \quad (1)$$

$$\lambda_i^{k+1} = V_i^{k+1} + \lambda_i^k \quad (2)$$

where λ_i and V_i are the current position and velocity of the particles, P_i and G are the best positions for particle and swarm. The parameters ω, $c_{1,2}$ and $r_{1,2}$ are the inertia weight, learning factors and random numbers in the range of $[0,1]$, respectively [5–7]. Learning coefficient c_1 is the cognitive learning factor while c_2 is the social learning factor which are positive constants. r random numbers are generated in each iteration [5, 6].

III. Transfer Function

A transfer function is described as a mapping process that gives visual properties to volume data. A simple transfer function is 1D function and maps scalar values to RGB or gray level and alpha values [8]. The volumetric visualization success rely on how well the transfer function acquires the features of interest [8, 9]. It is not easy to find an effective transfer function. Generally it is obtained by using a trial and error process [8, 10].

IV. Experiments

In this study we deal with finding the optimum opacity transfer function. The performance of the proposed method is examined on digital phantom images with size of 256x256x256.

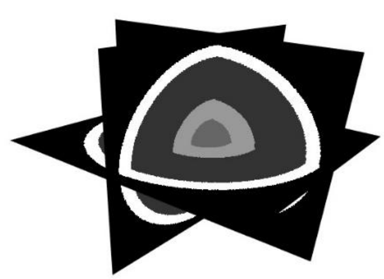


Figure 1: Volume slices

A representative of the phantom images is given in Fig.1. In the figure orthogonal slices which in different axes are shown.

In the experiments 1D opacity transfer function is used. Opacity values are optimized by using gradient means and probabilities of ROIs. According to ROIs, the opacity values are mapped to the intensity histogram bins by using PSO.

An example of 1D opacity transfer function optimized by PSO in the study is presented in Fig.2.

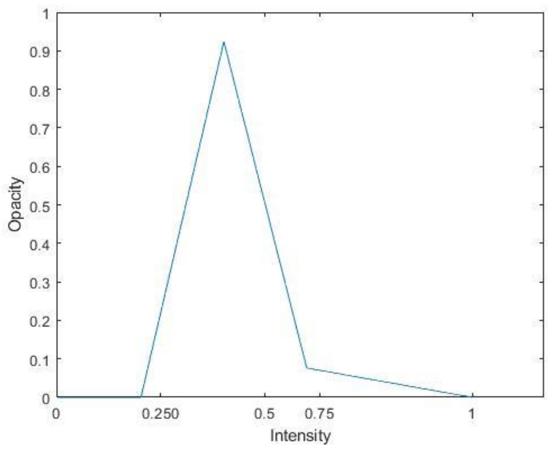
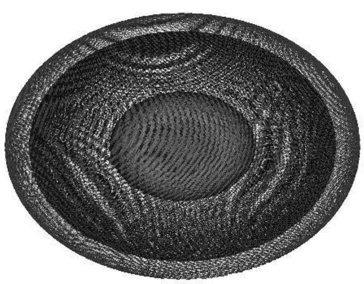


Figure 2: An example of 1D opacity transfer function

Visual results from experiments are shown in Fig.3. In the figure, different ROIs of volume can be seen in the rendered image.



a)

b)

c)

Figure 3: Visualized volumes for TF functions with different PSO solutions (a, b, c)

V. CONCLUSION

We propose a semi-automatic method based on PSO for finding the optimum opacity values of opacity transfer function. Based on the experiments it is shown that the proposed method has a promising performance on finding optimum opacity transfer function.

As a future study, we plan to optimize the transfer functions with PSO using color and opacity values.

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