Performance Enhancement of Differential Evolution by Incorporating Lévy Flight and Chaotic Sequence for the Cases of Satellite Images

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ABSTRACT

Differential Evolution (DE) is a simple but powerful evolutionary algorithm. Crossover Rate (CR) and Mutation Factor (F) are the most important control parameters in DE. Mutation factor controls the diversification. In traditional DE algorithm CR and F are kept constant. In this paper, the values of CR and F are modified to enhance the capability of traditional DE algorithm. In the first modified algorithm chaotic sequence is used to perform this modification. In the next modified algorithm Lévy Flight with chaotic step size is used for such enhancement. In the second modified DE, population diversity has been used to build population in every generation. As a result the algorithm does not converge prematurely. Both modified algorithms have been applied to optimize parameters of the parameterized contrast stretching function. The algorithms are tested for satellite image contrast enhancement and the results are compared, which show that DE via chaotic Lévy and population diversity information outperforms the traditional and chaotic DE in the image enhancement domain.

Keywords: Chaotic Sequence, Contrast, Differential Evolution, Image Enhancement, Lévy Flight

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1. INTRODUCTION

The goal of image enhancement is to process an image using some transformation function such that the resultant image is more suitable than the original one for some specific applications (Gorai and Ghosh, 2009). Image enhancement is essential in image processing field for various image processing applications like contrast enhancement, noise reduction, edge enhancement, edge restoration etc. during pre-processing of various kind of images especially those which having poor contrast. In the case of color image enhancement, one of the simple techniques is to separate the image into the chromaticity and intensity component and then apply transformation function on intensity component (Garg et al., 2011; Yang et al., 2003). One of the basic processes to enhance the images is histogram transformation (Leandro and Viviana, 2009). Histogram Equalization (HE) is a simple mechanism for image enhancement, but it has no control over the rate of enhancement. The enhanced image always follows the uniform distribution. The controlled enhancement can be done by putting limitations on the probability density function with the bin underflow (BU) and bin overflow (BO) (Yang et al., 2003). In literature different image enhancement techniques are proposed based on the histogram information; but enhancement in a controlled way is still a challenging problem. As a solution soft computing oriented methods have been applied recently. Evolutionary Algorithms (EAs) have been successfully applied in image enhancement and segmentation field where both these two are considered as optimization problem (Paulinas and Ušinskas, 2007; Snyers and Petillot, 1995; Coelho et al., 2009). Genetic Algorithm (GA) has been successfully applied to enhance the images in a controlled way (Snyers and Petillot, 1995; Pal et al., 1994; Hashemi et al., 2010). GA is also effectively used in image segmentation domain to give an optimal segmented image (Chun and Yang, 1996). GA performs well in medical image segmentation. Tissue of ultrasound image is segmented in a prominent way by genetic based incremental neural network (Dokur and Olmez, 2008). Differential evolution (DE) is a supreme version of GA. DE has the ability to grip non-differentiable, nonlinear, multi-modal cost functions and also has good convergence property (Liu et al., 2011). The efficiency of DE has also been proved in image enhancement domain (Yang, 2010). Application of DE is also found in the field of image fusion where DE is used for multi-focus image fusion to determine the suitable sizes of the block (Feng et al., 2011). An interactive DE algorithm has been applied for automatic image enhancement tool in smart phone (Lee and Cho, 2012). Mutation factor has been modified by chaotic sequence (Coelho et al., 2009) and the results show that modified DE is far better than traditional DE in image enhancement field maintaining faster convergence rate and better diversity property. Recently chaotic sequence has been used in metaheuristic algorithms to make it more powerful (Leandro and Viviana, 2009; Caponetto et al., 2003). Other metaheuristic algorithms have been successfully applied in image enhancement and segmentation domain (Braik et al., 2007; Singh and Pandey, 2012; Gorai and Ghosh, 2011; Gupta and Gupta, 2012; A., 2012; Ma et al., 2011; Yun-Fei et al., 2012). Hybrid meta-heuristic algorithms which combine two metaheuristic algorithms give more promising results, viz. harmony search which mimics the process of a music player (Liu et al., 2011).

In this paper, a simple parameterized contrast stretching technique has been used to for contrast enhancement of gray level satellite images which is described in section 2. DE with Lévy Flight and DE with chaotic sequence are proposed in section 3 to enhance those images by maximizing the fitness value. Here mutation factor and crossover rate of DE algorithm have been taken as a gray numbers and are modified by chaotic Lévy Flight and chaotic sequence to improve the efficiency the traditional DE algorithm. Lévy Flight can be useful to modify any parameter to get a global best parameter as it is a random walk (Yang, 2012; Yang and Deb, 2010). Chaotic sequences are also good to get global best solution in stochastic optimization.
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