

BIOGEOGRAPHY-BASED OPTIMIZATION TECHNIQUE FOR BLOCK-BASED MOTION ESTIMATION IN VIDEO CODING

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Abstract: Biogeography-Based Optimization (BBO) is a recently conceived bio-inspired optimization technique and population based evolutionary algorithm (EA). It mainly uses the idea of probabilistically sharing features between solutions based on the solutions' fitness values. Due to this feature, its exploitation ability is good. In this paper, we have demonstrated the performance of BBO for block motion estimation in video coding. Motion compensated video coding technique, which predicts current frame from previous frame (or reference frame), has been used to exploit the temporal redundancy between successive frames. The proposed technique is compared with existing search techniques. Experimental results show that the proposed technique provides competitive performance with reduced computational complexity.

1. INTRODUCTION

Motion Estimation (ME) is an important part of any video compression system, since it can achieve significant compression by exploiting the temporal redundancy existing in video sequence. The most computationally expensive and resource hungry operation in the entire compression process is motion estimation. Many fast ME algorithms are proposed to reduce the encoding time of the ME process. The existing search techniques are full search (FS), simple and efficient search (SES) [1], new three step search (NTSS) [2], four-step search (4SS) [3], diamond search (DS) [4-6], adaptive road pattern search (ARPS) [7]. There is stillroom for further improvement in the ME process. Therefore new optimization search techniques are searched with less computational cost and high visual quality. In this paper, authors applied BBO [8] for the motion estimation in video coding. The remainder of this paper is organized as follows. BBO is discussed shortly in section 2. Application of BBO for motion estimation in video coding is demonstrated in section 3, and conclusion is presented in section 4.

2. BIOGEOGRAPHY-BASED OPTIMIZATION

BBO is a new bio-inspired and population based optimization technique developed by Dan Simon in 2008 and is inspired by mathematical models of biogeography by Robert MacArthur and Edward Wilson [9]. BBO is applied to the sensor selection problem for aircraft engine health estimation and for general benchmark functions [8]. It has shown its ability to solve optimization problem like calculation of resonant frequency of rectangular microstrip patch antenna [10], standard power flow problem in power systems analysis [11]. Biogeography is the study of distribution of species in nature. Each possible

solution is an island and their features that characterize habitability are called suitability index variables (SIV). The goodness of each solution is called its habitat suitability index (HIS) [8]. In BBO, a habitat H is a vector of N (SIVs) initialized randomly and then follows migration and mutation step to reach global minima. In migration the information is shared between habitats that depend on emigration rates μ and immigration rates λ of each solution. Each solution is modified depending on probability P_{mod} that is a user-defined parameter. Each individual has its own λ and μ and are functions of the number of species K in the habitat and is expressed by equation (1) and (2) [8].

$$\lambda_k = \frac{EK}{P} \quad (1)$$

$$\mu_k = I \left(1 - \frac{K}{P} \right) \quad (2)$$

Where E = maximum λ , I = maximum μ , P = population size.

The immigration and emigration curves are straight lines for the case of $E=I$. Habitat with few species (low HIS, poor solution) has low μ and high λ , while habitat with more species (high HIS, good solution) high μ and low λ . Poor solutions accept more useful information from good solution, which improve the exploitation ability of algorithm.

Migration algorithm is described as follows [8]:

Select H_i with probability $\alpha \lambda_i$

If H_i is selected

For $j = 1$ to P

Select H_j with probability $\alpha \mu_j$

If H_j is selected

Randomly select an SIV σ from H_j

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                Replace a random SIV in  $H_i$  with  $\sigma$ 
            end if
        end for
    end if

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In BBO, the mutation is used to increase the diversity of the population to get good solutions. Mutation operator modifies a habitat's SIV randomly based on mutation rate m for the case of $E=I$. The mutation rate m is expressed as [8].

$$m(s) = pmutate \left(1 - \frac{P_i}{P_{max}} \right) \quad (3)$$

where, $pmutate$ is a user-defined parameter and $P_{max} = \text{argmax } P_i, i = 1, \dots, p$.

Mutation algorithm is described as follows [8]:

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For j = 1 to N
    Use  $\lambda_i$  and  $\mu_i$  to compute the probability  $P_i$ 
    Select SIV  $H_i(j)$  with probability  $\alpha P_i$ 
    If  $H_i(j)$  is selected
        Replace  $H_i(j)$  with a randomly generated SIV
    end if
end for

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BBO Algorithm is described as follows:

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Initialize Parameters:
P= population size
G= Maximum number of generation
Keep =Elitism parameter
 $P_{mod}$  =Island modification probability

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Step1: Initialize P randomly and species count
        probability of each Habitat
Step2: Evaluate the fitness for each individual in P
Step3: While The termination criteria is not met do
Step4: Save the best habitats in a temporary array
Step5: For each habitat, map the HSI to number of
        species S,  $\lambda$  and  $\mu$ 
Step6: Probabilistically choose the immigration
        island based on the immigration rates
Step7: Migrate randomly selected SIVs based on
        the selected island in Step6
Step8: Mutate the worst half of the population as
        Per mutation algorithm
Step9: Evaluate the fitness for each individual in P
Step10: Sort the population from best to worst
Step11: G=G+1
Step12: end while

```

3. MOTION ESTIMATION IN VIDEO CODING

Motion compensated video coding technique, which predicts current frame from previous frame (or reference frame), has been used to exploit the temporal redundancy between successive frames. Motion estimation plays an important role in such an interframe predictive coding system. Among many types of motion estimation algorithms, blockmatching technique has been adopted in many video compression standards, due to its simplicity. In motion estimation, the current image is divided into macro-blocks (MB) and for each MB, a similar one is chosen in reference frame, minimizing a distortion measure. The best match found represents the predicted MB, while the displacement from the original MB to the best match gives the so-called Motion Vector (MV). Only the MV and residual (i.e. the difference between the original MB and the predicted MB) are needed to encode and transmitted in to the final stream.

In this section, BBO is applied for motion estimation in video coding. The parameters of BBO are set as follows, a habitat H is a vector of N (SIVs), $P_{mod}=1$, immigration probability bounds per gene = $[0, 1]$, $E=I=1$, $keep=1$ and $pmutate=0.005$. A population member consists of a vector (SIVs) of integer numbers, with each element in the vector representing change in position of block. The positions of blocks are randomly initialized around a prediction vector and these are then passed as search space variables in search space domain of BBO. The fitness or HIS of a population member is calculated by taking mean absolute difference (MAD) between MB of current frame and reference frame and is expressed as (4).

$$MAD = \frac{1}{N^2} \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} |C_{ij} - R_{ij}| \quad (4)$$

where, N is the side of the MB, C_{ij} and R_{ij} are the pixels in current MB and reference MB.

In order to achieve a high-speed ME, threshold-based early termination strategies is implemented to quit the current search if the fitness of block matching satisfies the thresholds. This method is tested for caltrain and lecturer based video sequences. Video sequence with distance of one frames between current frame and reference frame are used to generate frame-by-frame results of the proposed algorithm. The performance of the proposed method is measured in terms of the average peak signal to noise ratio (PSNR) and the percentage of saving in the motion estimation time. PSNR is given as (5).

$$PSNR = 10 \log_{10} \frac{255^2}{\frac{1}{PQ} \sum_{i=1}^P \sum_{j=1}^Q (O_{ij} - CP_{ij})^2} \quad (5)$$

where, P, Q gives the size of the frame in video sequence, O_{ij} and CP_{ij} are the pixels in original frame and compensated frame. The results are compared with other existing methods and are presented in Table 1 and Table 2. Fig.1 and Fig. 2 show comparison of *PSNR* and computational time for caltrain video sequence. Fig. 3 and Fig. 4 shows original frame and motion compensated frame using BBO for the caltrain and lecture based video sequences.

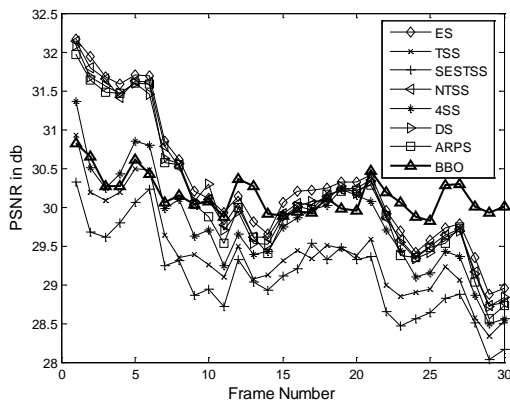


Fig. 1 Comparison of *PSNR* for caltrain video sequence

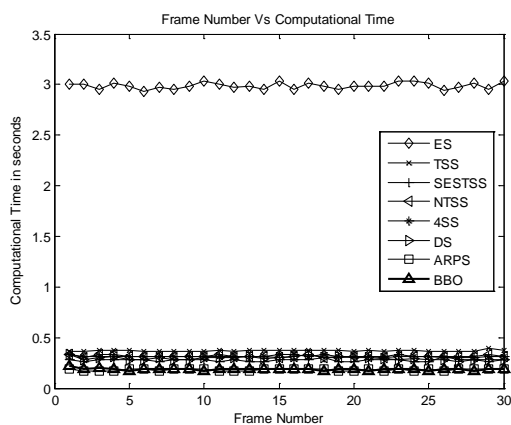


Fig. 2 Comparison of computational time for caltrain video sequence

4. CONCLUSIONS

In this paper, BBO is applied for the motion estimation in video coding. The results show that

presented technique is computationally faster than other methods keeping the comparable PSNR as compared with other methods. This method is tested for caltrain and lecturer based video sequences. An approximately more than 90% of computational time saving in the motion estimation coding is achieved as compared to ES algorithm. NTSS gives more PSNR but it takes large time. In future, the results can be improved by adaptively controlling the search range depending on the motion in the video and by improving the method of prediction vector.

5. ACKNOWLEDGEMENT

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Table 1 Comparison of mean PSNR (db) of Soft Computing Methods with other Methods

Sr. No.	Type of Video Sequence	No. of Frames	ES	TSS	SESTSS	NTSS	4SS	DS	ARPS	BBO
1	Caltrain	30	30.30	29.40	29.13	30.20	29.78	30.17	30.12	30.15
2	Lecturer Based	24	36.46	36.39	36.36	36.37	36.33	36.342	36.31	36.34

Table 2 Comparison of computational time of proposed method and existing methods

Sr. no	Type of video sequence	No. of Frames	Computational time in seconds							
			ES	TSS	SESTSS	NTSS	4SS	DS	ARPS	BBO
1	Caltrain	30	2.98	0.36	0.27	0.31	0.31	0.29	0.18	0.18
2	Lecturer based	24	4.36	0.54	0.42	0.44	0.41	0.38	0.25	0.27



(a)



(b)

Fig. 3 (a), (b) are the original and Motion compensated frames (Caltrain) using BBO.



(a)



(b)

Fig. 4 (a), (b) are the original and Motion compensated frames (Lecture based) using BBO.