Chapter 10
Frog Inspired Algorithms

Abstract In this chapter, we present two frog inspired computational intelligence (CI) algorithms, namely, shuffled frog leaping algorithm (SFLA) and frog calling algorithm (FCA). We first provide a brief introduction in Sect. 10.1. Then, the fundamentals and performance of SFLA are introduced in Sect. 10.2. Next, Sect. 10.3 outlines some core working principles and preliminary experimental studies relative to FCA. Finally, Sect. 10.4 summarises this chapter.

10.1 Introduction

In this chapter, we will introduce two computational intelligence (CI) algorithms that are inspired by some interesting behaviours exhibited by frogs (Wang et al. 2008; Mills et al. 2010; Rock et al. 2009; Reilly and Jorgensen 2011). These two algorithms are called shuffled frog leaping algorithm (SFLA) and frog calling algorithm (FCA), respectively.

10.2 Shuffled Frog Leaping Algorithm

10.2.1 Fundamentals of Shuffled Frog Leaping Algorithm

Shuffled frog leaping algorithm (SFLA) was recently proposed in (Eusuff and Lansey 2003; Eusuff et al. 2006; Eusuff 2004) for solving problems with discrete decision variables. Inspired by natural memetics, SFLA is a population-based cooperative search metaphor combining the benefits of the genetic-based memetic algorithm (MA) and the social behaviour based particle swarm optimization (PSO). Such algorithms have been developed to arrive at near-optimum solutions to complex and large-scale optimization problems which cannot be solved by gradient-based mathematical programming techniques.

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In SFLA, a population of randomly generated P solutions forms an initial population, where each solution called a frog is represented by an n-dimensional vector. SFLA starts with the whole population partitioned into a number of parallel subsets referred to as memeplexes. Then each memeplex is considered as a different culture of frogs and permitted to evolve independently to search the space. Within each memeplex, the individual frogs hold their own ideas, which can be affected by the ideas of other frogs, and experience a memetic evolution. During the evolution, the frogs may change their memes by using the information from the memeplex best or the best individual of entire population. Incremental changes in memo-types correspond to a leaping step size and the new meme corresponds to the frog's new position. In each cycle, only the frog with the worst fitness in the current memeplex is improved by a process similar to PSO.

In order to implement SFLA, the following procedures need to be followed (Eusuff and Lansey 2003; Eusuff et al. 2006; Eusuff 2004):

- Step 0: Setting $im = 0$ and $iN = 0$, where the number of memeplexes will be counted by im, and the number of evolutionary steps is recorded by iN.
- Step 1: Setting $im = im + 1$.
- Step 2: Setting $iN = iN + 1$.
- Step 3: Constructing a submemeplex. The weights are allocated based on a triangular probability distribution which is defined by Eq. 10.1 (Eusuff and Lansey 2003):

$$p_j = \frac{2(n + 1 - j)}{n(n + 1)}, \quad j = 1, 2, \ldots, n. \tag{10.1}$$

- Step 4: Improving the worst frog's location. In SFLA, the new position can be computed through Eq. 10.2 (Eusuff and Lansey 2003):

$$D_{(iq=q)} = D_W + d. \tag{10.2}$$

If $D_{(iq=q)}$ falls within the feasible space, then computing the new performance value $f_{(iq=q)}$; otherwise going to Step 5. If the new $f_{(iq=q)}$ is better than the previous $f_{(iq=q)}$, then replacing the old $D_{(iq=q)}$ with the new one and jumping to Step 7; otherwise, going to Step 5.

- Step 5: If previous step (i.e., Step 4) could not generate a better solution, then computing the step and the new position for frog based on the present global optimal solution.
- Step 6: Censorship. If the frog's new location is either unsuitable or no good than the old one, the spread of defective meme is terminated by stochastically generating a new frog at a suitable position to replace the frog whose new position was not possible to move towards an optimum value.
- Step 7: Upgrading the memeplex.
- Step 8: If $iN < N$, returning to Step 2.

- Step 9: If $im < m$, returning to Step 1; otherwise performing shuffling operation to create new memeplex sets.

10.2.2 Performance of SFLA

To verify the efficacy of SFLA, the New York City Water Supply Tunnel System case study was employed in (Eusuff and Lansey 2003). The simulation results showed that SFLA was capable to find previous best solutions for two example networks and a near optimal solution for the third case. In comparison with other CI techniques (e.g., genetic algorithm (GA), simulated annealing (SA), etc.), the SFLA converged within fewer iteration rounds which make it a versatile tool in dealing with optimization problems.

10.3 Emerging Frog Inspired Algorithm

In addition to the aforementioned SFLA, the characteristics of this interesting animal also motivate researchers to develop another frog inspired innovative CI algorithm.

10.3.1 Frog Calling Algorithm

10.3.1.1 Fundamentals of Frog Calling Algorithm

Frog calling algorithm (FCA) was originally proposed in (Mutazono et al. 2012) for dealing with power consumption issue in the context of wireless sensor networks. Inspired by Japanese tree frog calling (or satellite) behaviour, a self-organizing scheduling scheme was presented in (Mutazono et al. 2012) to achieve a energy-efficient data transmission. To fully utilize the FCA, the following three factors have to be considered (Mutazono et al. 2012):

- Factor 1: Territory. A frog will first check that if there is any calling frog in its own territory range, and then it will confirm that if the total number of calling frogs existing in the paddy field is still within an acceptable range. Once it is done with these, it will decide to produce calls or not.
- Factor 2: Number of competing frogs. A frog will evaluate its surroundings and compare itself with other calling frogs according to some criteria. If the probability for the frog to win is high, it will begin to call anyway.
- Factor 3: Body size. Once the weak calling frog detects its current condition, it will adopt sleep strategy to avoid competition.

10.3.1.2 Performance of FCA

Mutazono et al. (2012) tested the proposed FCA on a single-hop network. The preliminary computer simulation results demonstrated that proposed FCA method extends network lifetime by a factor of 6.7 in comparison with the method without sleep control strategy for a coverage ratio of 80 %.

10.4 Conclusions

In this chapter, we presented two frog inspired CI algorithms, namely, SFLA and FCA. Although they both are newly introduced CI methods, we have witnessed the following rapid spreading of at least one of them, i.e., SFLA.

First, several enhanced versions of SFLA can be found in the literature as outlined below:

- Binary SFLA (Gómez-González and Jurado 2011).
- Chaos-based SFLA (Li et al. 2008; Zhang et al. 2011).
- Clonal selection-based SFLA (Bhaduri 2009).
- Composite SFLA (Zhang et al. 2010).
- Discrete SFLA (Baghmisheh et al. 2011).
- Hybrid SFLA (Rahimi-Vahed and Mirzaei 2007; Rao and Lakshmi 2012; Niknam and Farsani 2010; Luo et al. 2009a; Farahani et al. 2010; Khorsandi et al. 2011; Niknam et al. 2012b).
- Improved SFLA (Malekpour et al. 2012; Zhang et al. 2008; Zhen et al. 2009; Jahani et al. 2011c; Li et al. 2012b).
- Modified SFLA (Huynh 2008; Nejad et al. 2010a, b; Narimani 2011; Elbeltagi et al. 2007; Jahani et al. 2010, 2011a ; Niknam et al. 2011b, c; Luo et al. 2009b; Roy and Chakrabarti 2011; Pu et al. 2011; Ahandani et al. 2011; Zhang et al. 2012).
- Multiobjective SFLA (Rahimi-Vahed et al. 2009; Liu et al. 2011a, 2012; Wang and Gong 2013; Li et al. 2010; Niknam et al. 2011a).
- Tribe-based SFLA (Niknam et al. 2012a).

Second, the SFLA has also been successfully applied to a variety of optimization problems as listed below:

- Bridge life cycle management (Elbehairy 2007; Elbehairy et al. 2006).
- Circuit design (Zhu and Zhi 2012).
- Controller design optimization (Huynh 2008).
- Data mining (Amiri et al. 2009; Liu et al. 2011a, 2012).
- Image processing (Bhaduri 2009; Wang et al. 2010).
- Laminate composite structures optimization (Rao and Lakshmi 2011).
- Manufacturing optimization (Rahimi-Vahed and Mirzaei 2007; Pakravesh and Shojaei 2011).

- Network virtualization (Liu et al. 2011b).
- Power system optimization (Rameshkhah et al. 2010a, b, 2011; Nejad et al. 2010a; Gómez-González and Jurado 2011; Narimani 2011; Sedighizadeh et al. 2011; Payam et al. 2011; Bijami et al. 2011; Jahani et al. 2010, Jahani et al. 2011a, b; Jalilzadeh et al. 2011; Ebrahimi et al. 2011; Yammani et al. 2012; Malekpour et al. 2012; Niknam and Farsani 2010; Nejad et al. 2010b; Niknam et al. 2011a, b, c, 2012b; Khorsandi et al. 2011; Roy and Chakrabarti 2011).
- Project management (Elbeltagi et al. 2007).
- Robot control (Pu et al. 2011).
- Scheduling optimization (Rahimi-Vahed et al. 2009; Tavakolan 2011; Rahimi-Vahed and Mirzaei 2008; Pan et al. 2011; Fang and Wang 2012; Li et al. 2012a; Wang and Fang 2011).
- Travelling salesman problem (Xue-Hui et al. 2008; Luo et al. 2009b).
- Water resource management (Eusuff and Lansey 2003; Eusuff 2004; Mora-Meliá et al. 2010; Chung 2007; Chung and Lansey 2009; Pasha and Lansey 2009; Seifollahi-Aghmiuni et al. 2011; Li et al. 2010).

Interested readers are referred to them as a starting point for a further exploration and exploitation of frog inspired algorithms.

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