# Chapter 15
# Imperialist Competitive Algorithm

**Abstract** In this chapter, we present a new optimization algorithm called imperialist competitive algorithm (ICA) which is inspired by the human socio-political evolution process. We first describe the general knowledge of the imperialism in Sect. 15.1. Then, the fundamentals and performance of ICA are introduced in Sect. 15.2. Finally, Sect. 15.3 summarises this chapter.

## 15.1 Introduction

In politics and history, in order to explain the extending control over weaker people or areas, the term "empire" is appeared. One of the famous examples is the Roman Empire from 27 BC to 476. The most powerful person is usually called imperialist and different imperialists will extent their authority and control of one state or people over another through the form of competition. Inspired by this human socio-political evolution process, a newly developed evolutionary algorithm called Imperialist competitive algorithm (ICA) is proposed by Atashpaz-Gargari and Lucas (2007).

### *15.1.1 Imperialism*

Imperialism was greatly influenced by an economic theory known as mercantilism which inspired the government to extend their power and the rule beyond its own boundaries (Atashpaz-Gargari and Lucas 2007). In its initial forms, due to the limited supply of wealth, counties focused on building their empire with natural resources, such as gold and silver. However, nowadays the new imperialism focused on the new technological advances and developments. The ultimate goal is to increase the number of their colonies and spreading their empires over the world.

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## 15.2 Imperialist Competitive Algorithm

### 15.2.1 Fundamentals of Imperialist Competitive Algorithm

Imperialist competitive algorithm (ICA) was originally proposed by Atashpaz-Gargari and Lucas (2007). In ICA, the countries can be viewed as population individuals and basically divided into two groups based on their power, i.e., colonies and imperialists. Also, one empire is formed by one imperialist with its colonies. Furthermore, two operators called assimilation and revolution and one strategy called imperialistic competition are the main building blocks that employed in ICA. The implementation procedures are described as below (Atashpaz-Gargari and Lucas 2007):

- Initializing phase:

1. Preparation of initial populations. Each solution (i.e., *country*) that in form of an array can be defined via Eq. 15.1 (Atashpaz-Gargari and Lucas 2007):

$$country = [p_1, p_2, \ldots, p_{N_{\mathrm{var}}}], \tag{15.1}$$

   where $p_i s$ represent different variables which based on various socio-political characteristics (such as culture, language, and economical policy), and $N_{\mathrm{var}}$ denotes the total number of the characteristics (i.e., $n$–dimension of the problems) to be optimized.
2. Creating the cost function. In order to evaluate the cost of countries, the cost function can be defined via Eq. 15.2 (Atashpaz-Gargari and Lucas 2007):

$$\cos t = f(country) = f(p_1, p_2, \ldots, p_{N_{\mathrm{var}}}). \tag{15.2}$$

3. Initializing the empires: In general, the initial size of populations ($N_{pop}$) involves two types of countries [i.e., colony ($N_{col}$) and imperialist ($N_{imp}$)] which together form the empires. To form the initial empires proportionally, the normalized cost of an imperialist is defined via Eq. 15.3 (Atashpaz-Gargari and Lucas 2007):

$$NC_n = c_n - \max_i\{c_i\}, \tag{15.3}$$

   where $c_n$ is the cost of $n$th imperialist, $NC_n$ denotes its normalized cost.

Normally, two methods can be used to divide colonies among imperialist: (1) from the imperialists' point of view which based on the power of each imperialist; (2) from the colonies' point of view which based on the relationship with the imperialist (i.e., the colonies should be possessed by the imperialist according to the power). Both methods are given via Eqs. 15.4 and 15.5, respectively (Atashpaz-Gargari and Lucas 2007):

$$Power_n = \left| \frac{NC_n}{\sum_{i=1}^{N_{imp}} NC_i} \right|, \tag{15.4}$$

$$NOC_n = round\{Power_n, N_{col}\}, \tag{15.5}$$

where $Power_n$ is the normalized power of each imperialist, $N_{col}$ and $N_{imp}$ represent the number of all colonies and imperialists, respectively, and $NOC_n$ is the initial number of colonies of $n$th empire.

- Moving phase:

1. Assimilation strategy: According to this strategy, all colonies will move toward their relevant imperialist with $x$ units via Eq. 15.6 (Atashpaz-Gargari and Lucas 2007):

$$x \sim U(0, \beta \times d), \tag{15.6}$$

   where $x$ is a random variable with uniform distribution, $\beta$ is a number greater than 1, and $d$ is the distance between a colony and an imperialist.

2. Revolution strategy: According to this strategy, a random amount of deviation to the direction of movement is incorporated via Eq. 15.7 (Atashpaz-Gargari and Lucas 2007):

$$\theta \sim U(-\gamma, \gamma), \tag{15.7}$$

   where $\theta$ is a random variable with uniform distribution, and $\gamma$ is a parameter that adjusts the deviation from the original direction.

- Exchanging phase: Based on the cost function, when the new position of a colony is better than that of the corresponding imperialist, the imperialist and the colony change their positions and the new location with lower cost becomes the imperialist.
- Imperialistic competition phase:

1. Calculating the total power of an empire: It is influenced by the power of imperialist country and the colonies of an empire via Eq. 15.8 (Atashpaz-Gargari and Lucas 2007):

$$TC_n = Cost(imperialist_n) + \xi\, mean\{Cost(colonies\, of\, empire_n)\}, \tag{15.8}$$

   where $TC_n$ is the total cost of the $n$th empire, and $\xi$ is a positive number which is considered to be less than 1.

2. Imperialistic competition strategy: According to this strategy, all empires try to take the possession of the colonies of other empires and control them. To

modelled this strategy, the weakest colonies of the weakest empires will be chose to competition among all other empires in order to possess this colony. Based on $TC_n$, the normalized total cost is simply obtained via Eq. 15.9 (Atashpaz-Gargari and Lucas 2007):

$$NTC_n = TC_n - \max_i\{TC_i\}, \quad (15.9)$$

where $NTC_n$ represents the total normalized cost of $n$th empire. Having $NTC_n$, the possession probability of each empire is evaluated via Eq. 15.10 (Atashpaz-Gargari and Lucas 2007):

$$P_{p_n} = \left| \frac{NTC_n}{\sum_{i=1}^{N_{imp}} NTC_i} \right|. \quad (15.10)$$

- Eliminating phase: When an empire loses all its colonies (i.e., their colonies will be divided among other empires), it is assumed to be collapsed and will be eliminated.
- Convergence phase: At the end, all the colonies will be under the control of the most powerful empire, which means all the colonies have the same positions and same costs and will be controlled by an imperialist with the same position and cost as themselves. In other words, there are no difference not only among colonies but also between colonies and imperialist.

Taking into account the key phases described above, the steps of implementing ICA can be summarized as follows (Atashpaz-Gargari and Lucas 2007):

- Step 1: Defining the optimization problem.
- Step 2: Generating initial empires by pick some random points on the function.
- Step 3: Move the colonies towards imperialist states in different directions (i.e., assimilation).
- Step 4: Random changes occur in the characteristics of some countries (i.e., revolution).
- Step 5: Position exchange between a colony and imperialist.
- Step 6: Compute the total cost of all empires.
- Step 7: Use imperialistic competition and pick the weakest colony from the weakest empire.
- Step 8: Eliminate the powerless empires.
- Step 9: Check if maximum iteration is reached, go to Step 3 for new beginning. If a specified termination criteria is satisfied stop and return the best solution.

### *15.2.2 Performance of ICA*

In order to show how the ICA performs, four minimization problems are tested in Atashpaz-Gargari and Lucas (2007). Compared with genetic algorithm (GA) and particle swarm optimization (PSO), the results showed that ICA is capable of reaching the global minimum.

## 15.3 Conclusions

In this chapter, an optimization algorithm motivated by one of the socio-politically models (i.e., imperialistic competition) is introduced. The term "countries" are designed as the initial populations and categorized into colony and imperialist states, respectively. Both colonies and imperialist together form the empires. The basic idea behind ICA is to lead the search process toward the powerful imperialist or the optimum points based on their "power", i.e., the weakest empires will lost their colonies until there will be no colony in that. The objective of ICA is to find an ideal world in which there is no difference not only among colonies but also between colonies and imperialist. Although it is a newly introduced computational intelligence method, we have witnessed the following rapid spreading of ICA:

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

- Bacterial foraging optimization based ICA (Acharya et al. 2010).
- Chaotic improved ICA (Talatahari et al. 2012a, b).
- Constrained genetic algorithm based ICA (Acharya et al. 2010).
- Fast ICA (Acharya et al. 2010).
- Hybrid artificial neural network and ICA (Taghavifar et al. 2013).
- Hybrid evolutionary algorithm and ICA (Ramezani et al. 2012).
- Modified ICA (Niknam et al. 2011).
- Multiobjective ICA (Bijami et al. 2011; Mohammadi et al. 2011).
- Quad countries algorithm (Soltani-Sarvestani et al. 2012).

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

- Artificial neural network training (Moadi et al. 2011).
- Assembly line balancing (Bagher et al. 2011).
- Data mining (Ghanavati et al. 2011; Niknam et al. 2011).
- Facility location optimization (Mohammadi et al. 2011; Moadi et al. 2011).
- Power system optimization (Nejad and Jahani 2011; Bijami et al. 2011).
- Product mix-outsourcing problem (Nazari-Shirkouhi et al. 2010).
- Scheduling optimization (Forouharfard and Zandieh 2010; Ayough et al. 2012; Lian et al. 2012; Kayvanfar and Zandieh 2012).

- Soil compaction prediction (Taghavifar et al. 2013).
- Structure design optimization (Talatahari et al. 2012b).

Interested readers please refer to them as a starting point for a further exploration and exploitation of ICA.

## References

Acharya, D. P., Panda, G., & Lakshmi, Y. V. S. (2010). Effects of finite register length on fast ICA, bacterial foraging optimization based ICA and constrained genetic algorithm based ICA algorithm. *Digital Signal Processing, 20*, 964–975.

Atashpaz-Gargari, E., & Lucas, C. (2007). Imperialist competitive algorithm: An algorithm for optimization inspired by imperialistic competition. In *IEEE Congress on Evolutionary Computation (CEC 2007)* (pp. 4661–4667). IEEE.

Ayough, A., Zandieh, M., & Farsijani, H. (2012). GA and ICA approaches to job rotation scheduling problem: Considering employee's boredom. *International Journal of Advanced Manufacturing Technology, 60*, 651–666.

Bagher, M., Zandieh, M., & Farsijani, H. (2011). Balancing of stochastic U-type assembly lines: An imperialist competitive algorithm. *International Journal of Advanced Manufacturing Technology, 54*, 271–285.

Bijami, E., Abshari, R., Askari, J., Hosseinnia, S., & Farsangi, M. M. (2011). Optimal design of damping controllers for multi-machine power systems using metaheuristic techniques. *International Review of Electrical Engineering, 6*, 1883–1894.

Forouharfard, S., & Zandieh, M. (2010). An imperialist competitive algorithm to schedule of receiving and shipping trucks in cross-docking systems. *International Journal of Advanced Manufacturing Technology, 51*, 1179–1193.

Ghanavati, M., Gholamian, M. R., Minaei, B., & Davoudi, M. (2011). An efficient cost function for imperialist competitive algorithm to find best clusters. *Journal of Theoretical and Applied Information Technology, 29*, 22–31.

Kayvanfar, V., & Zandieh, M. (2012). The economic lot scheduling problem with deteriorating items and shortage: An imperialist competitive algorithm. *International Journal of Advanced Manufacturing Technology*. doi:10.1007/s00170-011-3820-6.

Lian, K., Zhang, C., Shao, X., & Gao, L. (2012). Optimization of process planning with various flexibilities using an imperialist competitive algorithm. *International Journal of Advanced Manufacturing Technology, 59*, 815–828.

Moadi, S., Mohaymany, A. S., & Babaei, M. (2011). Application of imperialist competitive algorithm to the emergency medical services location problem. *International Journal of Artificial Intelligence and Applications (IJAIA), 2*, 137–147.

Mohammadi, M., Tavakkoli-Moghaddam, R., & Rostami, H. (2011). A multi-objective imperialist competitive algorithm for a capacitated hub covering location problem. *International Journal of Industrial Engineering Computations, 2*, 671–688.

Nazari-Shirkouhi, S., Eivazy, H., Ghodsi, R., Rezaie, K., & Atashpaz-Gargari, E. (2010). Solving the integrated product mix-outsourcing problem using the imperialist competitive algorithm. *Expert Systems with Applications, 37*, 7615–7626.

Nejad, H. C., & Jahani, R. (2011). A new approach to economic load dispatch of power system using imperialist competitive algorithm. *Australian Journal of Basic and Applied Sciences, 5*, 835–843.

Niknam, T., Fard, E. T., Ehrampoosh, S., & Rousta, A. (2011). A new hybrid imperialist competitive algorithm on data clustering. *Sādhanā, 36*, 293–315.

Ramezani, F., Lotfi, S., & Soltani-Sarvestani, M. A. (2012). A hybrid evolutionary imperialist competitive algorithm (HEICA). In J.-S. Pan, S.-M. Chen & N. T. Nguyen (Eds.) *ACIIDS 2012, Part I, LNAI 7196* (pp. 359–368). Berlin: Springer.

Soltani-Sarvestani, M. A., Lotfi, S., & Ramezani, F. (2012). Quad countries algorithm (QCA). In J.-S. Pan, S.-M. Chen & N. T. Nguyen (Eds.) *ACIIDS 2012, Part III, LNAI 7198* (pp. 119–129). Berlin: Springer.

Taghavifar, H., Mardani, A., & Taghavifar, L. (2013). A hybridized artificial neural network and imperialist competitive algorithm optimization approach for prediction of soil compaction in soil bin facility. *Measurement, 46*, 2288–2299.

Talatahari, S., Azar, B. F., Sheikholeslami, R., & Gandomi, A. H. (2012a). Imperialist competitive algorithm combined with chaos for global optimization. *Communications in Nonlinear Science and Numerical Simulation, 17*, 1312–1319.

Talatahari, S., Kaveh, A., & Sheikholeslami, R. (2012b). Chaotic imperialist competitive algorithm for optimum design of truss structures. *Structural and Multidisciplinary Optimization*. doi:10.1007/s00158-011-0754-4.