Container Traffic Prediction in a Seaport Stockyard Implementing Artificial Bee Colony Algorithm Compared with the Genetic Algorithm

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Abstract

After finishing the construction stage of a container terminal, it is very difficult to modify the current port configuration and properties. For this instance, to avoid of the sunk costs, it is crucial for the seaport designers to predict the container traffic at any stage of the design phase. One of the important facilities of a seaport is the container stockyard in which the containers are held for handling operations. The preliminary design of this facility directly influenced by the container traffic and the probable container amount at the stock area. Hence, the required size of the stock area is determined and the further construction costs are directly related with this design parameter. This study proposed a forecasting model for obtaining the daily value of the containers in the stockyard. The proposed model is a simple regressed model with the past records of container traffic in the storage area. The model results showed that, artificial bee colony algorithm successfully predicted the model coefficients even better than genetic algorithm. The results indicated that the model performance is sufficient for predicting the contain amount in a seaport considering the observed records.

Keywords — Container traffic, artificial bee colony, container stock yard, genetic algorithm,

1 Introduction

Forecasting the container traffic in a seaport is important for a reliable and functional seaport design. Due to the nonlinear characteristics, the seaport container traffic is difficult to be forecasted. In many cases, regression analysis, exponential smoothing methods are applied for this task. In literature there are many studied forecasting the container traffic and determining the capacity of the handling facilities. [1] developed a methodology to find the optimum tonnage capacity of the cargo in a seaport, which should be handled with a specific number of berths. [2] implemented an integrated process simulation model, for planning and optimization of container stockyard layouts.[3] focused on the simulation of the freight transport traffic where the logistic operators load and unload processes take place in the Seville seaport. [4] combined optimization of continuous berth and quay crane allocation problem in seaport container terminal.[5] addresses the berth allocation planning problems using simulation and optimization with Arena software. [6] provided a methodology, supported with a simulation tool, to determine the required stockyard size for dry bulk terminals. In this case study, the proposed approach was demonstrated by sizing the required stockyard area for a specific import terminal. [7] attempted to create an optimal predictive model of volumes of container throughput at ports by using genetic programming

2 Methodology

2.1 Artificial Bee Colony

The Artificial Bee Colony (ABC) algorithm, simulates the foraging behavior of three kinds of honey bee, i.e. employed bees, onlooker bees and scout bees [8]. The ABC algorithm is a kind of an iterative procedure similar to other swarm based algorithms. Initially, a population consist of a number of food-sources is randomly generated and for each source that particular solution is considered as a candidate solution for the corresponding optimization problem. The food sources are considered by three types of bees. For the first type, a new food source is created according to the available one using an employed bee, and corresponding fitness value is calculated. According to the second kind, the food source of a specific employed bee is further modified by an onlooker bee. Later, the fitness value of the altered food source is determined. For the last type of bees, a novel food source is arbitrarily created to update the untouched one in the whole population using a scout bee. After several iteration, the best food source obtained is kept and reserved as the best solution of the corresponding optimization problem. Figure 1 depicts the pseudo-code of the ABC process.

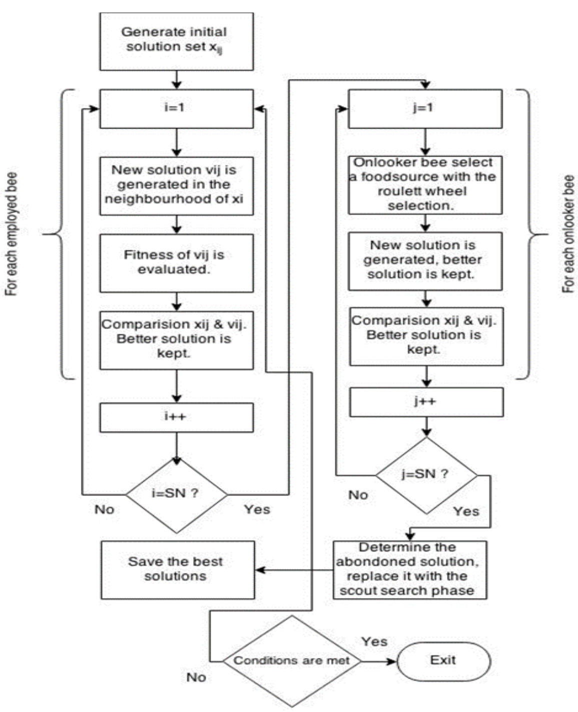

Figure 1. Flow chart of the ABC algorithm

2.2 Mathematical Model

In the scope of the modelling phase, the container traffic records [9] were obtained and evaluated. The storage area has three sources of inputs as sea, railroad and trucks while the railroad traffic is so small and considered as negligible in the analysis. The required data gathered from the port authorities of Izmir seaport according to a two year period of recording as monthly-based observations. A simple regression model considering the one, two, three and four days lag of input and output container amounts in the storage area is used fort he genetic algorithm study so in the scope of the model configuration, a single container is no longer stay at the stock area more than four days. The input values of the model are the net container flow to the storage area (coming –outgoing containers) as shown in mathematical form as Eq.1

$$ST = \sum X_1(i)K_t(i) + \sum X_2(i)G_t(i) + \sum X_3(i)Z_t(i) \qquad (1)$$

In the equation above, ST is the current amount of containers present in the storage area. X_1,X_2 and X_3 are the coefficients of the net container movements correlating the container amount of the present day with the historical records In the modelling phase, the X_1 X_2 and X_3 vectors are the parameters to be optimized in the genetic algorithm. The K G and Z indices are defined as the net amount of containers added or taken from the stock area by truck (K) by (ship) and by train (Z). Also "i" is a symbol defining the lag as if i=1 than it indicates the same day and i=2 is the previous day. In this instance K(3) represents the amount of containers added or subtracted from the stock yard space two days ago. The ABC algorithm used for training the neural network parameters instead of the popular back-propagation training algorithm. Instead of back propagating the network error, the connection weights between the nodes were considered as the optimized parameters while the network error was the goal function to be optimized.

2.3 Genetic Algorithm

Genetic algorithm (GA) in a kind of evolutionary optimization based on the survival of the fittest principle. It requires an initial population of parameters. The solution of the problem is encoded by genes combined as chromosomes. Each chromosomes indicates a singular solution to the problem. The probable solutions are randomly scattered in the search space. In this study the individual genes are the coefficients of the regression model. Once the initial population is initialized, reproduction produces new generations of individuals; the best individual survives and generates the next generation. Crossover stage used for switching the nodes between two individuals fort the same population.

3 Analysis and Discussion

Izmir seaport, operated by Turkish government, is an export hub in western Anatolia of Turkey [10]. The İzmir city is the third largest city of Turkey with a population over 4 million and is its an economically important city with its exports corresponded to 6% and its imports 4% of Turkey's foreign trade [11]. The seaport is connected to the railway and highway networks. Plan view of the Izmir seaport is shown in Figure 2. The daily arriving and departing containers rate in Twenty-foot equivalent unit (TEU) is shown in Figure 3 and Figure 4.

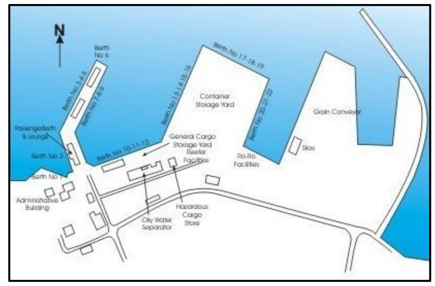

Figure 2. Plan view of the Izmir seaport. [12]

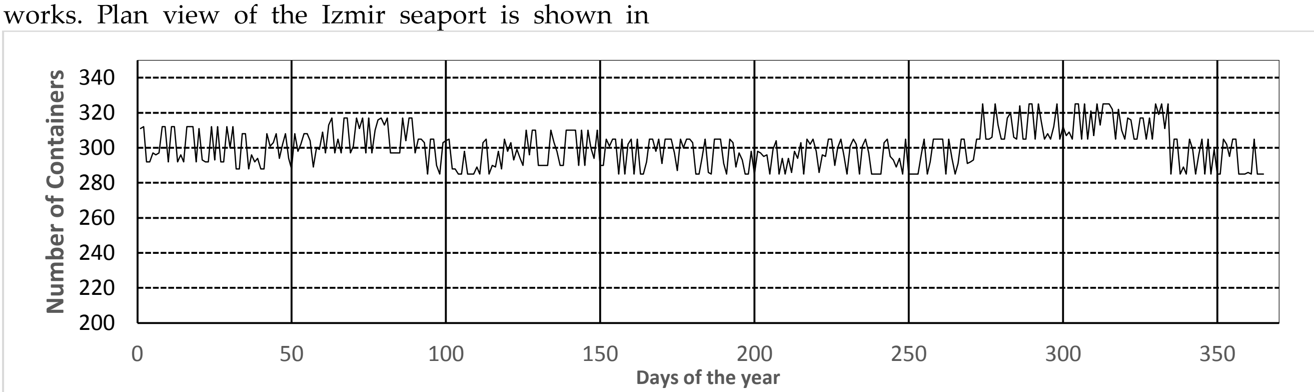

Figure 3.Daily arriving containers in TEU[9]

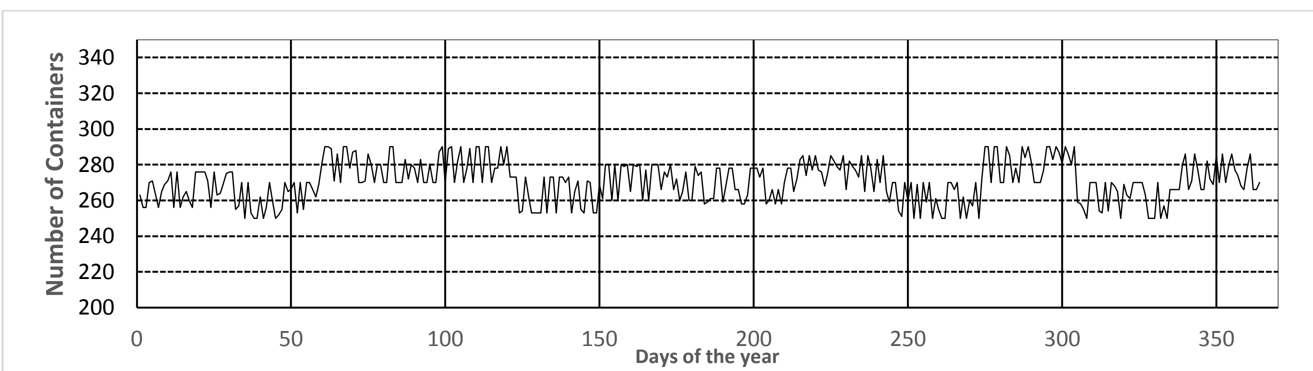

Figure 4. Daily departing containers in TEU[9]

Table 1. Parameters of the ABC algorithm

Parameters of the ABC algorithm	Value
Number of variables to be optimized	12
Population size	50
Number of solutions	12
Performance criterion	Mean square error
Stopping criteria	Max 500 cycles

In the ABC algorithm, several parameters were used as shown in Table 1. In the modelling phase Matlab is used as the coding environment.

After the optimization progress of the model parameters, the configured model was used for predicting the one-a-day-head containers in the storage area. The calculated and observed containers in the storage area are shown in Figure 4 below in monthly basis. The model parameters optimized for each month are shown in the Table 2. The table also includes the fitness function. By comparing the observed and predicted values for all months and for each single month, it is concluded that model results represents a well suit with the real data.

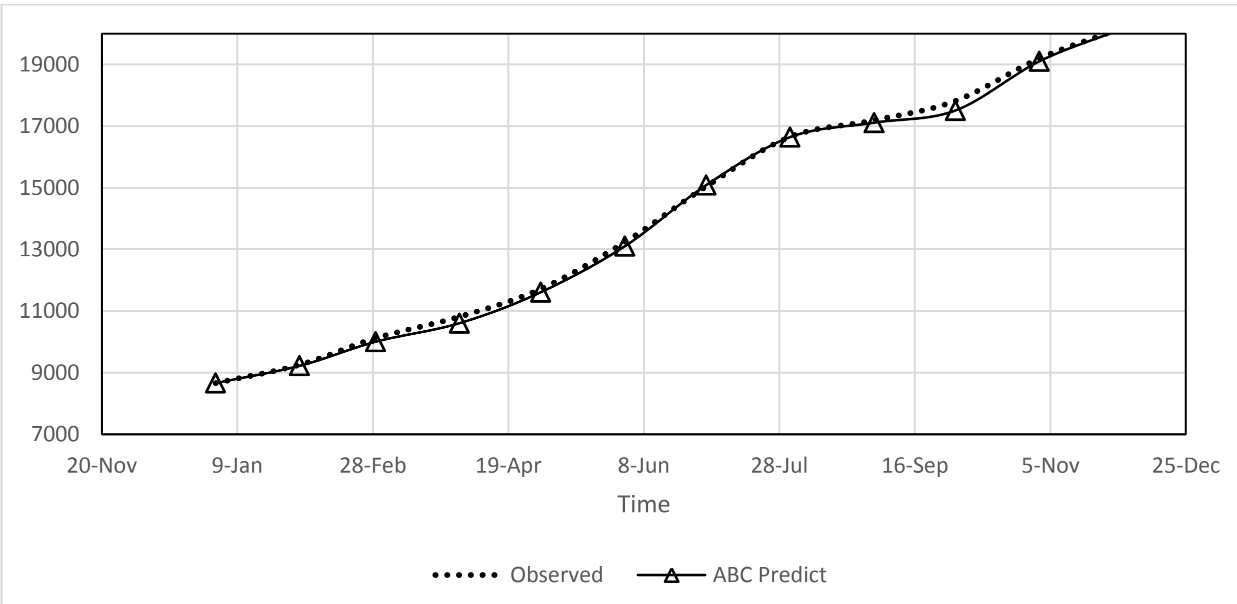

Figure 5. Calculated and predicted container amounts in the storage area in monthly basis.

Table 2. Fitness function values and model parameters for the ABC model.

MONTHS	X(1)	X(2)	X(3)	X(4)	X(5)	X(6)	X(7)	X(8)	X(9)	X(10)	X(11)	X(12)	FitFNC
Jan	0.044671	0.185741	-0.05933	-0.14711	-0.16517	0.11652	-0.00509	-0.0985	-0.02791	-0.11985	0.058625	0.082434	-0,036
Feb	0.054877	0.078598	-0.08694	0.086699	0.100686	0.002046	0.057819	-0.10054	-0.04158	0.086173	-0.02816	-0.11271	-0.027
Mar	0.032729	0.118766	0.035841	-0.18114	-0.17657	0.09121	0.070046	-0.15329	0.062931	-0.19446	-0.02995	0.087946	-0.021
Apr	0.132387	0.193245	0.194437	0.160403	-0.00422	-0.18369	0.151166	0.138703	-0.19557	0.19529	-0.17423	0.080742	-0.013
May	-0.19357	0.055135	0.022473	-0.01064	0.116919	-0.07414	0.026781	0.111677	-0.12214	-0.09759	0.081805	0.167301	-0.028
June	-0.14818	0.160663	-0.09406	0.064089	0.057851	-0.1594	0.081645	0.11885	0.025325	-0.14016	-0.06761	0.071931	-0,013
July	-0.00405	0.141826	0.14024	-0.0734	0.066834	0.041392	-0.1825	0.180711	0.041359	-0.04639	0.155433	0.101231	-0,021
Agu	-0.15799	0.099896	0.004526	-0.12599	-0.17575	0.182056	-0.19601	-0.15401	-0.04543	-0.101	0.087477	0.19876	-0,022
Sep	-0.00365	0.053793	-0.03243	-0.17164	-0.06152	-0.17449	-0.12079	0.193598	0.119093	-0.17723	-0.19169	0.18195	-0,020
Oct	0.021142	0.07457	0.156961	-0.17996	0.112282	0.122131	0.02345	-0.19307	-0.05406	0.118131	-0.1514	-0.06989	-0,012
Nov	0.044671	0.185741	-0.05933	-0.14711	-0.16517	0.11652	-0.00509	-0.0985	-0.02791	-0.11985	0.058625	0.082434	-0,011
Dec	0.054877	0.078598	-0.08694	0.086699	0.100686	0.002046	0.057819	-0.10054	-0.04158	0.086173	-0.02816	-0.11271	-0,012

Genetic algorithm (GA) is a innovative way of solving the constrained or unconstrained optimization problems implementing biological selection similar to the nature [13]. The algorithm tried to alter the population for individual solutions in a repeatedly way. The same data were used for proposing the genetic algorithm model by a different study of the authors [14]. The model results are shown in Figure 5 below.

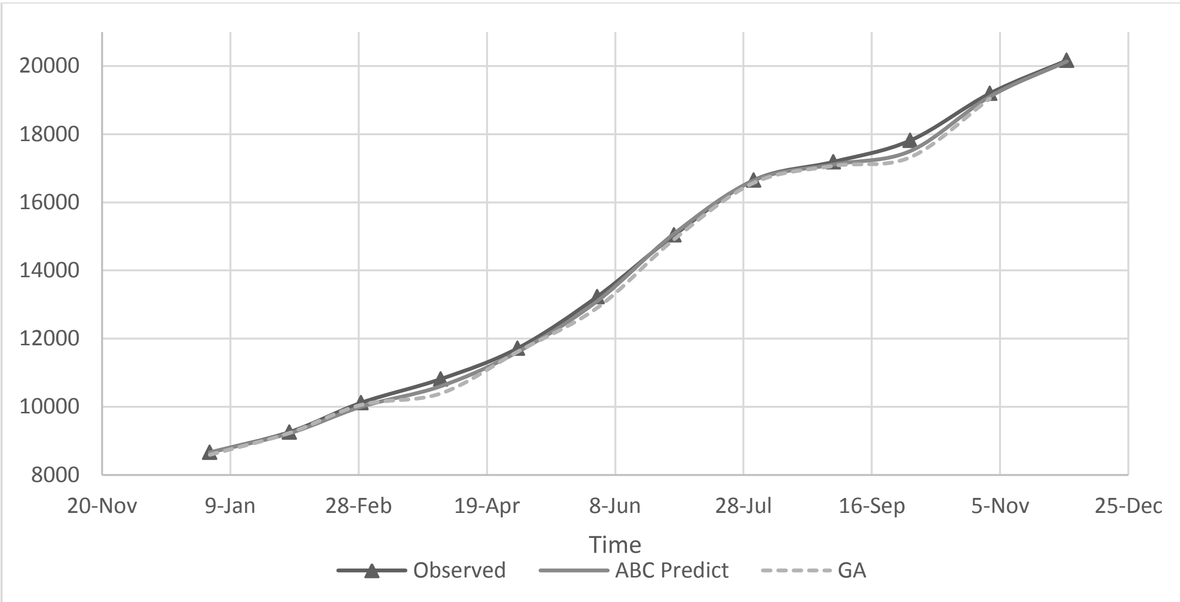

Figure 5.Calculated and predicted container amounts in the storage area in monthly basis by implementing the genetic algorithm model and ABC model.

Table 5. Comparison of fitness function values and model parameters for the ABC and GA model.

Algorithm Type	Jan	Feb	Mar	Apr	May	June	July	Agu	Sep	Oct	Nov	Dec
GA	-0,036	-0.040	-0.026	-0.017	-0.029	-0,014	-0,022	-0,027	-0,023	-0,015	-0,015	-0,013
ABC	-0,036	-0.027	-0.021	-0.013	-0.028	-0,013	-0,021	-0,022	-0,020	-0,012	-0,011	-0,012

4 Conclusion

Comparing with the observed data, the ABC model proposed for predicting a-day-ahead container amount by regressing the past records of container traffic is found to be reasonable. The comparison were made considering the real container traffic records of 2002 in Izmir seaport [9]. Model results also indicated relatively larger deviations comparing with the monthly averages. The proposed model also can be used for performing a simulation of the stock area for the case of high traffic and the maximum amount of containers probable to be observed in the stock area was found as 20098 TEU. This is also a reasonable prediction comparing with the real observed amount of 20165 TEU. The deviations between the calculated and observed values can be described by the fact that, there exist many model parameters. The previous study [14] of the authors indicated the possibility of using genetic algorithm to determine the optimal parameters fort the regression model for forecasting the container values in the stock yard of the seaport. The previous stock area value was 19913 TEU was far more deviated from the real observed amount. This study also demonstrated the applicability of the neural networks trained with the ABC algorithm for the same purpose. The comparison of these two study clearly indicated that, the ABC model slightly showed increased forecasting performance comparing with the genetic algorithm model.

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