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October 15, 2019 AI techniques 3 Comments

Dolphin Echolocation Algorithm (DEA): A Novel Method Motivated from the Behavior of Dolphin for Optimal Solution

1. Introduction

Dolphin Echolocation Algorithm is mimics strategies used by dolphins for their hunting process. Dolphins produce a kind of voice called sonar to locate the target, doing this dolphin change sonar to modify the target and its location. In order to implement the optimization task an improved dolphin echolocation meta-heuristic algorithm is proposed. In dolphin echolocation algorithm, the echolocation behavior of dolphins is simulated to search the design space of the optimization problem [1]. The numerical results demonstrate the superiority of the proposed meta-heuristic over its standard version. Furthermore, it is observed that the performance-based layout optimization process finds structural configurations which are about 10 % lighter than those of obtained by the pure sizing optimization. The strategies used by Dolphins in their hunting process were mimicked to propose Dolphin echolocation (DE) (Kaveh and Farhoudi 2013) metaheuristic and the results presented in (Kaveh and Farhoudi 2013) demonstrated the superiority of DE over the GA, HS, ACO, ABC, PSO, ICA and some hybrid algorithms in solving steel structure optimization problems. The DA is an optimization technique based on the behavior and the echolocation feature of the dolphins [2]. By using a high-frequency click they are able to find a potential prey, all around the search space. Then, incrementally, the dolphins increase its clicks for the purpose of concentrate the search in that region. Understanding the habitat preferences and fine scale distributions of the two species is important for conservation management, particularly ensuring that adequate protection is provided for both bottlenose dolphin and harbor porpoise populations. This study examined the spatio-temporal fluctuations in the distribution and occurrence of bottlenose dolphins and harbor porpoises within Cardigan Bay SAC with implications for future management. We used static passive acoustic monitoring and modeling to examine fine scale seasonal, diel and tidal changes in the presence of dolphins and porpoises at selected hotspots [3].

The integration model seems to provide a better account of the dolphin's performance than a decision model that does not combine information from multiple echoes. Although it does not prove that dolphins similarly combine information from multiple echoes, in the absence of relevant neuro physiological evidence, it provides support or such a hypothesis. It also suggests the potential benefits to be derived for pattern recognition from combining multiple samples from the same target. During the daily echolocation tests the animals' eyes are covered with soft removable eyecups that completely occlude its vision. Echolocation data were recorded while the animal was performing a delayed matching-to-sample (DMTS) object recognition task. In this task, the dolphin must select from a set of three alternatives the one target that is the same as (matches) a previously presented sample target [4].

2. Inspiration of Dolphin Echolocation Algorithm

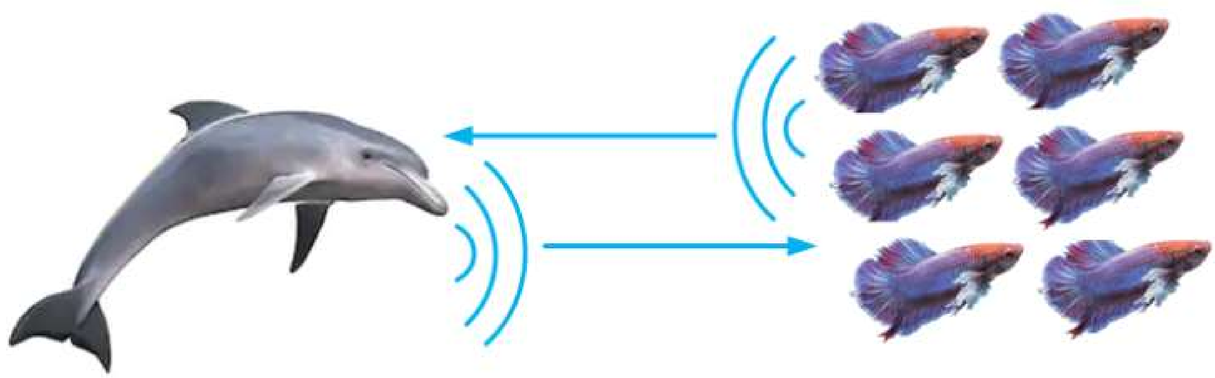

Fig 1: A real dolphin catching its prey

3. Dolphin Echolocation Algorithm

Dolphin is generally acknowledged as one of the smartest animals and it has a lot of interesting biological characteristics and living habits worth our attention [5].

Echolocation: Dolphin has good eyesight, but the good eyesight helps the dolphin little with predation in poor light conditions. Instead, the dolphin uses a special ability to search for prey, which is echolocation [6]. Dolphin is one of the few creatures that are adept at using echolocation. It can make sounds and estimate the location, distance, and even the shape of the prey according to echo intensity. With the help of echo, the dolphin can have a better perception of the surrounding environment [7].

Cooperation and division of labor: In most cases, predatory behavior is not achieved by one dolphin alone but by the joint efforts of many dolphins through cooperation and division of labor. Facing large preys, the predatory behavior is unlikely to be achieved by only one dolphin. In such a case, the dolphin calls other dolphins for help with predation. Moreover, there is a specific division of labor between the dolphins. For instance, the dolphins close to the prey are responsible for tracking the movements of the prey and the dolphins far away from the prey form a circle to surround the prey [8].

Information exchanges: Current studies show that dolphins have the ability to exchange information. They can express different ideas by using sounds at different frequencies and have their own language system. In the predatory process, especially under cooperation and division of labor, the ability of exchanging information is frequently used to call other dolphins and update the location of the prey [9]. With the help of information exchanged, the dolphin can take better suited actions to make the predation more effective. The whole process of dolphin's predation consists of three stages. In the first stage, each dolphin independently takes advantage of sounds to search for nearby preys and to evaluate the surrounding environment using echoes. In the second stage, dolphins exchange their information. The dolphins that find large preys call other dolphins for help. The dolphins that have received information move toward the prey and surround it along with other dolphins. In the last stage, the prey is surrounded by the dolphins and then what the dolphins need to do is to take turns to enjoy the food, which means that predation is accomplished [10]. Although dolphins are widespread, most species prefer the warmer waters of the tropic zones, but some, like the right whale dolphin, prefer colder climates. Dolphins feed largely on fish and squid, but a few, like the killer whale, feed on large mammals, like seals. Male dolphins typically mate with multiple females every year, but females only mate every two to three years. Calves are typically born in the spring and summer months and females bear all the responsibility for raising them. Mothers of some species fast and nurse their young for a relatively long period of time. Dolphins produce a variety of vocalizations, usually in the form of clicks and whistles [11].

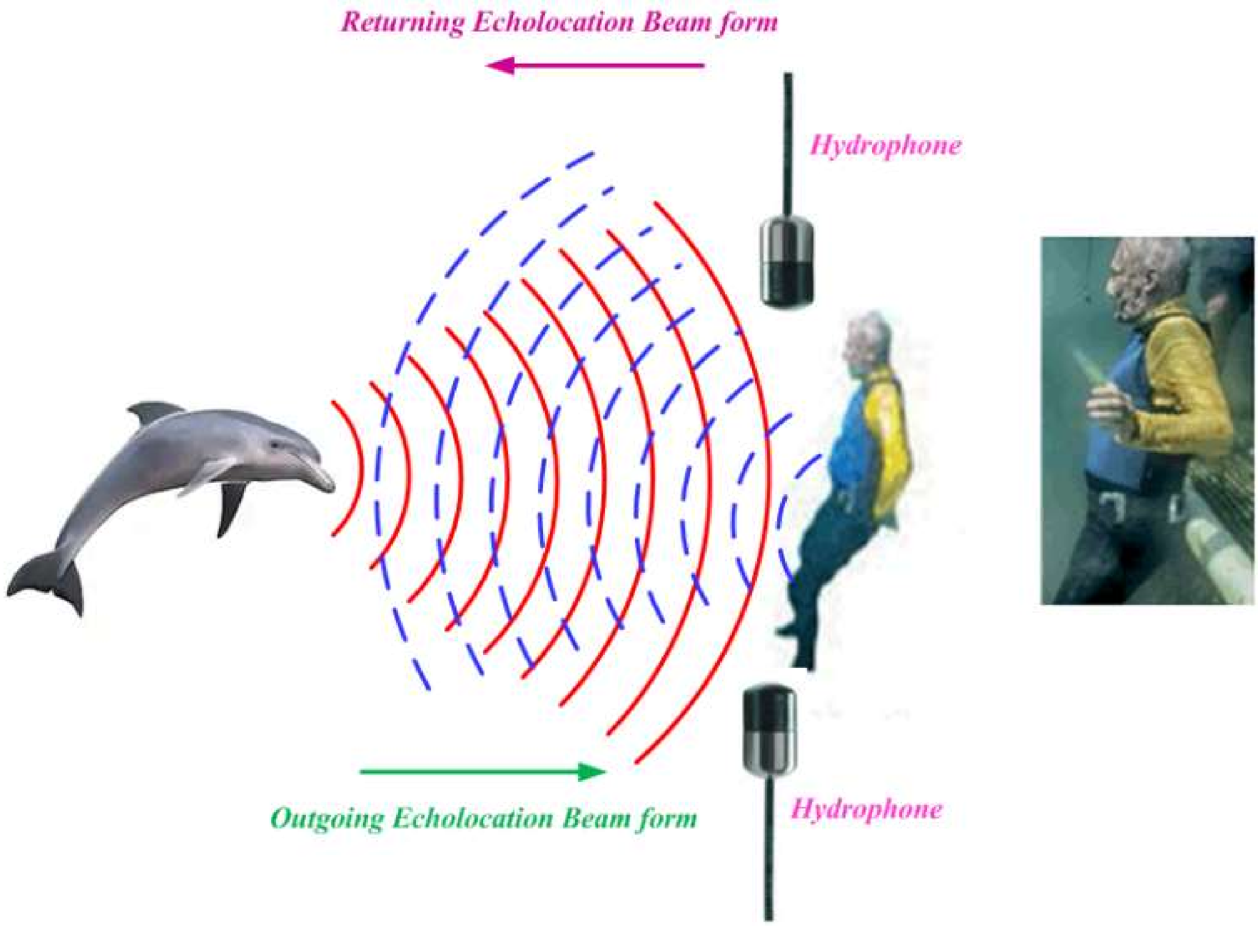

Fig 2: Dolphin Echolocation Algorithm

3.1. Steps for Dolphin Echolocation Algorithm

- Initiate
- Fitness of each location [12]
- Calculate the accumulative fitness
- Best location [13]
- Termination

3.1.1. Initiate

Create the initial locations randomly, which includes the generating the random numbers. Equivalent to sonar or radar, echolocation is the production of sound used for communication. Echolocation is the use of ultra-high frequency sounds for navigation and locating prey [14]. Bats and marine mammals are able to use sound to "see". Echolocation is used by mammals like dolphins, whales.

3.1.2. Fitness of each location

Fitness is the basis for judging whether the solution is better. In DEA, It is calculated by a fitness function and the closer it is to zero, the better it is [15]. Because the fitness functions corresponding to different optimization problems are also different, for better understanding, the fitness function, and specific examples of this fitness function can be found. Fitness should be defined in a manner that the better answers get higher values. In other words the optimization goal should be to maximize the fitness [16].

3.1.3. Calculate the accumulative fitness

The number of dolphins interacting during the optimization, the initialization of the pod in terms of position and velocity, the set of coefficients controlling the pod dynamics, and finally the method used to handle the box constraints [17].

3.1.4. Best Location

This is while, in dolphin echolocation algorithm there is no movement to the best answer. DE algorithm works with possibilities. Echolocation is a process that permits dolphins to send out sound waves that when they hit an object, are bounced back, allowing them to identify the location, shape, and size of such object. Echolocation or bio sonar is the ability of some animals to locate objects through sound waves, that is, sounds [18].

3.1.5. Termination Echolocation is a process that permits dolphins to send out sound waves that when they hit an object, are bounced back, allowing them to identify the location, shape, and size of such object [19]. The process of evolution of dolphins gave them this ability that allowed them to survive in the aquatic environment [20].

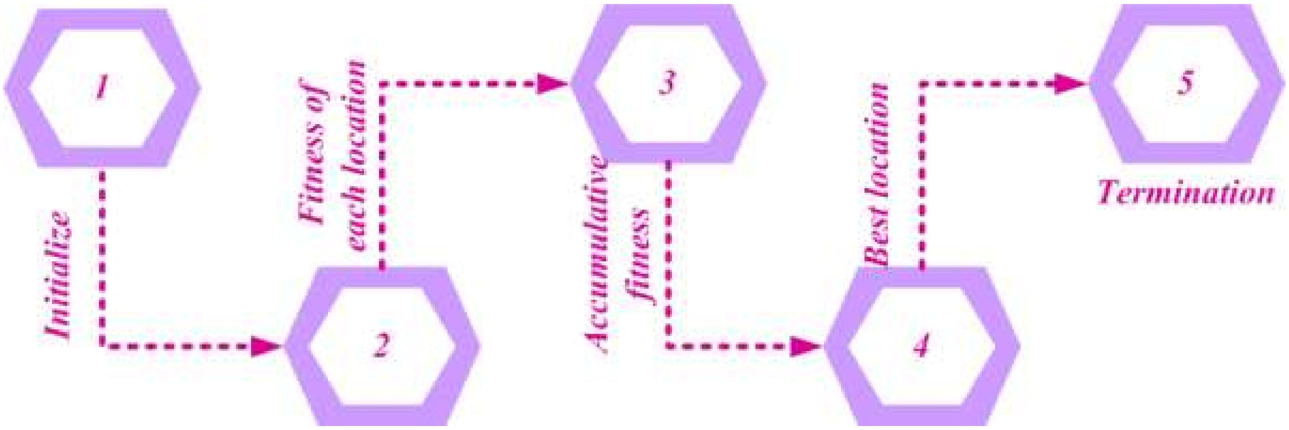

Fig 3: Steps for Dolphin Echolocation Algorithm

3.2. Flow Chart of DEA

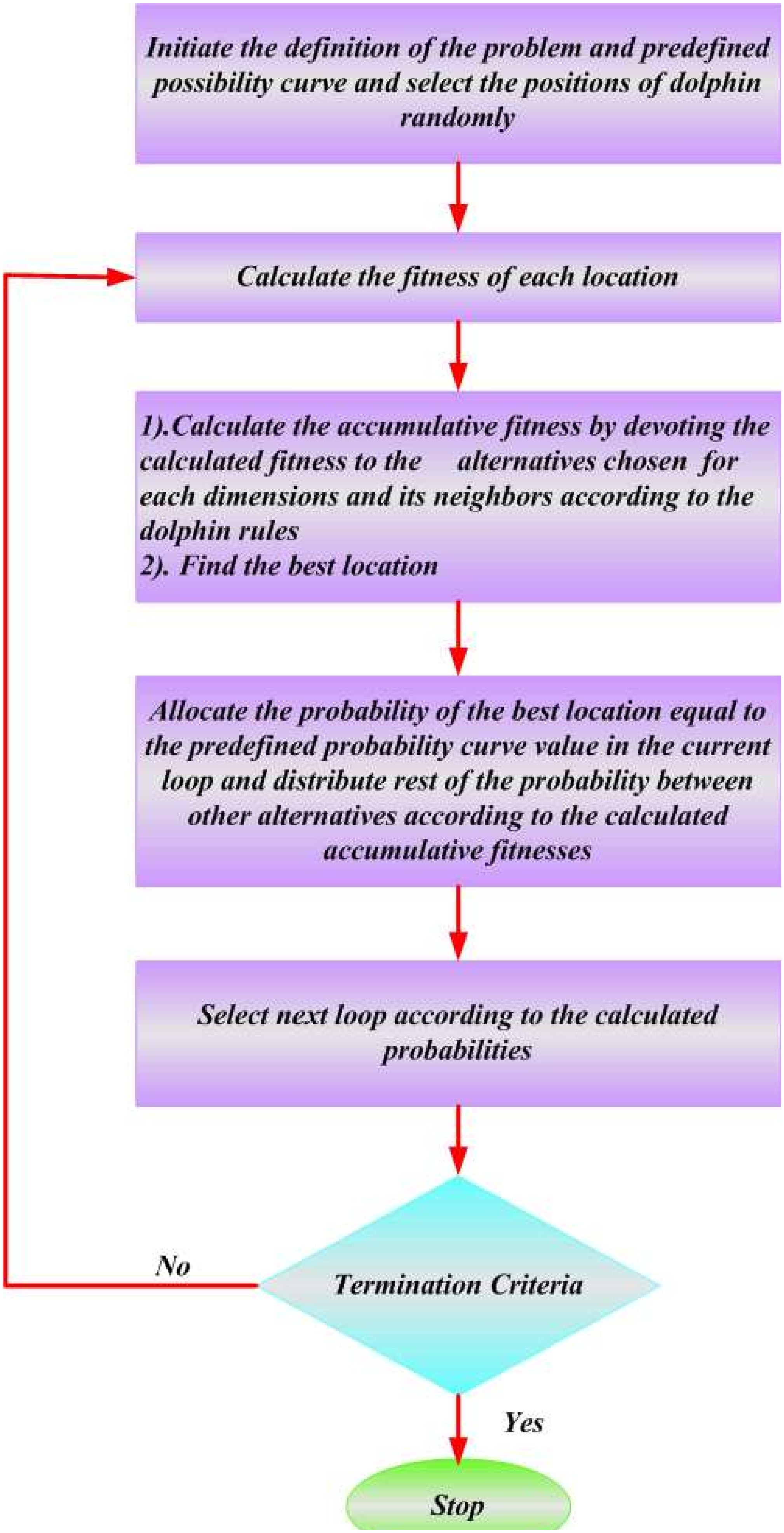
Initiate the definition of the problem and predefined possibility curve and select the positions of dolphin randomly
Calculate the fitness of each location
1).Calculate the accumulative fitness by devoting the calculated fitness to the alternatives chosen for each dimensions and its neighbors according to the dolphin rules
2). Find the best location
Allocate the probability of the best location equal to the predefined probability curve value in the current loop and distribute rest of the probability between other alternatives according to the calculated accumulative fitnesses
Select next loop according to the calculated probabilities
Termination Criteria
No
Yes
Stop

Fig 4: Flow Chart of Dolphin Echolocation Algorithm

3.3. Parameters of Algorithm

Input parameters for the Algorithm are [21]:

(a) Loops number

For an optimization algorithm it is beneficial for the user to be able to dictate the algorithm to work according to the affordable computational cost. The answers may obviously be dependent on the selected number of loops and will improve by an increase in the loops number. However, the point is that one may not achieve results as bad as those of other optimization algorithms gained in less loops, because in this case although the algorithm quit its job much sooner than expected, the answer is good because of convergence criteria being reached. The number of loops can be selected by sensitivity analysis when high accuracy is required, however, in structural optimization of normal buildings, the loops number is recommended to be more than 50.

(b) Convergence curve formula

This is another important parameter to be selected for the algorithm. The curve should reach to the final point of 100% smoothly. If the curve satisfies the above mentioned criteria the algorithm will perform the job properly, but it is recommended to start with a linear curve and try the curves that spend more time (more loops) in high values of the PP. For example, if one is using proposed curves of this paper, it is recommended to start with Power = 1 which usually gives good results and it is better to try some cases of the Power < 1 to check if it improves the results.

(c) Effective radius

This parameter is better to be chosen according to the size of search space. It is recommended to be selected less than 1/4 of the size of the search space.

Then for sample location,

```
for i = L_i
  for j = 1 to 4
    find the position of L(i,j) in the j^th column of the Alternatives matrix and name
     it as A
    for k = -10 to 10
      AF_(A+k)j = 1/10 * (10 - |k|) Fitness(Li) + AF_(A+k)j
    end
  end
end
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$$AF_{(A+k)j} = \frac{1}{10} * (10 - |k|) Fitness(Li) + AF_{(A+k)j}$$

4. Numerical Example for Dolphin Echolocation Algorithm

The numerical example of Dolphin Echolocation Algorithm is given [22], Minimize $f(x) = 0.622x_1x_3x_4 + 1.7781x_2x_3^2 + 3.1661x_1^2x_4 + 19.84x_1^2x_3$

$0.01 \leq x_1, x_2 \leq 6$

$10 \leq x_3, x_4 \leq 200$

$f(x) = 0.622 \times 1.5 \times 10 \times 15 + 1.7781 \times 2.5 \times 10^2 + 3.1661 \times 1.5^2 \times 15 + 19.84 \times 1.5^2 \times 10$

$= 139.95 + 444.525 + 106.85 + 446.4$

$= 1137.725$

$g_1(x) = 0.0193x_3 - x_1 \leq 0$

$= 0.0193 \times 10 - 1.5$

$= -1.307$

$g_2(x) = 0.00954x_3 - x_2 \leq 0$

$= 0.00954 \times 10 - 2.5$

$= -2.4$

$g_3(x) = x_4 - 240 \leq 0$

$= 15 - 240$

$= -225$

Minimize $f(x) = 1.1047x_1^2x_2 + 0.04811x_3x_4(14.0 + x_2)$

$0.1 \leq x_1 \leq 2.0$

$0.1 \leq x_2 \leq 10$

$0.1 \leq x_3 \leq 10$

$0.1 \leq x_4 \leq 2.0$

$f(x) = 1.1047x_1^2x_2 + 0.04811x_3x_4(14.0 + x_2)$

$= 1.1047 \times 1^2 \times 5 + 0.04811 \times 7 \times 1.5(14.0 + 5)$

$= 5.5235 + 8.587$

$= 14.11$

$g_4(x) = x_1 - x_4 \leq 0$

$= 1 - 1.5$

$= -0.5$

$g_5(x) = 0.125 - x_1 \leq 0$

$= 0.125 - 1$

$= -0.875$

$g_6(x) = 1.1047x_1^2x_2 + 0.04811x_3x_4(14.0 + x_2) - 5 \leq 0$

$= 1.1047 \times 1^2 \times 5 + 0.04811 \times 7 \times 1.5(14.0 + 5) - 5$

$= 5.5235 + 8.587 - 5$

$= 14.11 - 5$

$= 9.11$

4.1. Example

DE achieves the best answer in approximately 50 loops and near 80loops. HPSACO reaches to the same result in around 100 loops. It should be mentioned that Kaveh and Talatahari show that the HPSACO itself has better convergence rate in comparison to GA, PSO, PSOPC and HPSO.

Optimal cross sectional areas (in^2)									
Element group	Wu & chow [23] GA	Lee & Geem [24] HS	Li et al [25] PSO	Li et al [25] PSOPC	Li et al [25] HPSO	Keveh & Talatahari HPSACO[26] in^2	Keveh & Talatahari HPSACO[26] cm^2	Present work in^2	Present work cm^2
1	0.40	0.01	0.01	0.01	0.01	0.01	0.07	0.01	0.07
2	2.00	2.00	2.00	2.00	2.00	1.60	10.32	1.60	10.32
3	3.60	3.60	3.60	3.60	3.60	3.20	20.65	3.60	20.65
4	0.01	0.01	0.01	0.01	0.01	0.01	0.07	0.01	0.07
5	0.01	0.01	0.01	0.01	0.01	0.01	0.07	0.01	0.07
6	0.80	0.80	0.80	0.80	0.80	0.80	5.16	0.80	5.16
7	2.00	2.00	2.00	2.00	2.00	2.00	12.90	2.00	12.90
8	2.40	2.40	2.40	2.40	2.40	2.40	15.40	2.40	15.40
weight	563.52	560.59	560.44	560.59	560.59	551.6	250.2	551.6	250.2

5. Applications of DEA

- Steel braced frame [27]
- Manufacturing cell design problems
- Sonar
- Signal processing
- Travelling Salesman Problem [28]
- Gabor Wavelets

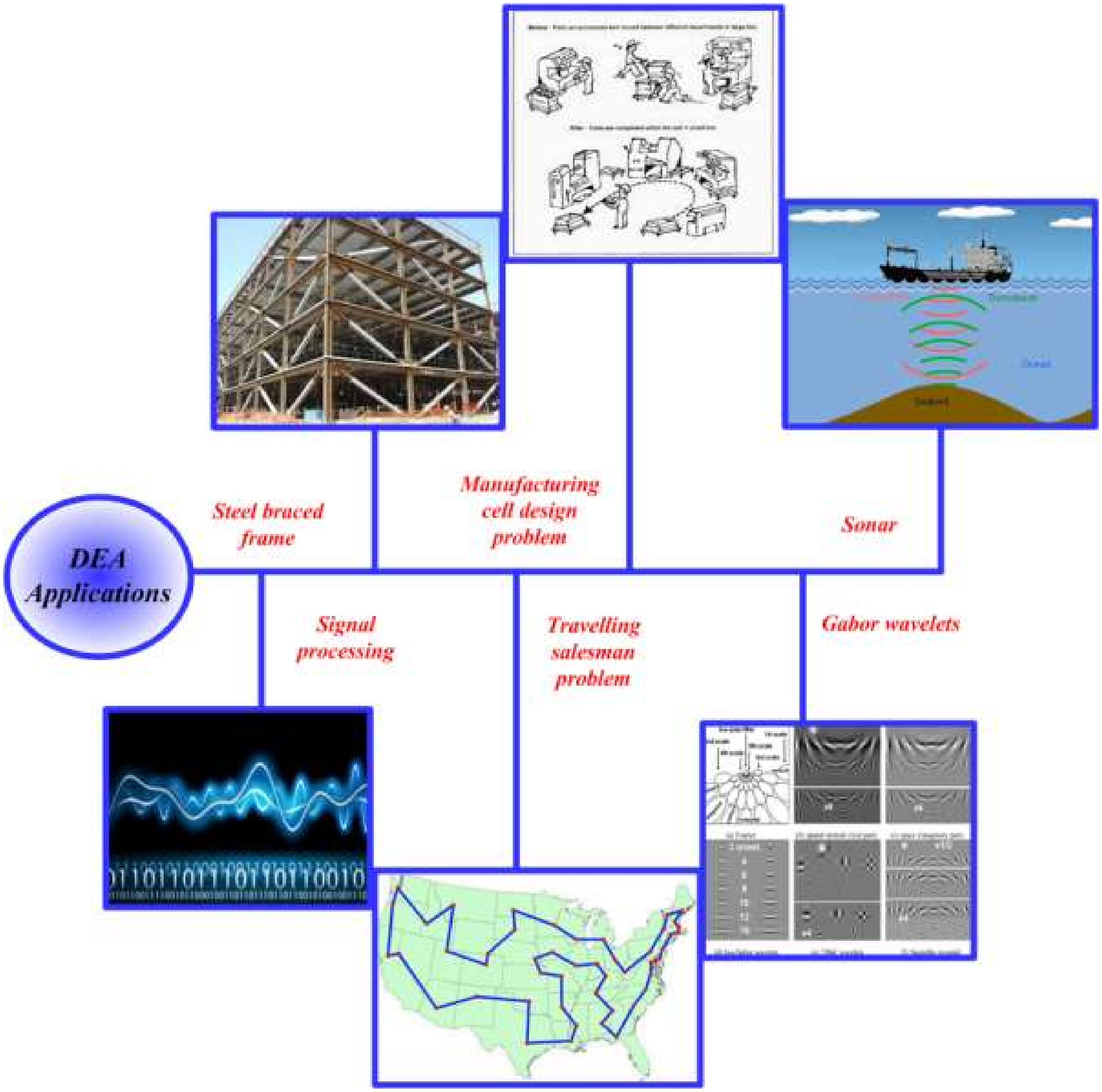

Fig 5: Applications of Dolphin Echolocation Algorithm

6. Advantages of DEA

- This feature is used by the dolphin to search all around the search space for a target, and then the dolphin exploits the surround area in order to find promising solutions.
- The dolphin swarm algorithm is particularly appropriate to optimization problems, with more calls of fitness functions and fewer individuals [29].
- One of the famous combinatorial hard problems of Traveling Salesman Problem (TSP) is being chosen as the test bed.
- Independent Component 2 Various Sources of Acoustic Signals Analysis (ICA) has been successfully used for the separation of independent sound

sources in many applications.

- Small-target identification by echolocation, which realizes the object identification strategy used by dolphins, is discussed [30].
- Gabor image that contains a noise free grayscale representation of the fundamental dolphin whistle which is re sampled and fed into the Sparse Representation Classifier.

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