VOL. 9, NO. 9, SEPTEMBER 2014 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

# THE SURVEY OF OPTIMAL DECISION TECHNIQUE FOR SOLVING COMPUTATIONAL PROBLEMS: THE APPLICATIONS OF EINSTEIN'S GENERAL THEORY OF RELATIVITY

G. M. Wali Ullah
Department of Mathematics, Univrsity of Chittagong, Bangladesh
E-Mail: waliullah_cu@yahoo.com

**ABSTRACT**

The paper surveys computational procedures for the optimal decision problem. Advantages of Ying. *et al*'s proposed concept, are illustrated. The proposed algorithm is encouraged by a simulation of several asteroids shifting within a universe to search for the body with heaviest mass. By referring to the Einstein's general theory of relativity, an algorithm is designed to obtain optimal point.

**Keywords:** optimal decision, Einstein's general theory of relativity, numerical methods, algorithms.

## 1. INTRODUCTION

The paper initiates a survey for finding the optimal method for solving computational problems. In 1995, Kennedy and later in 1999, Dorigo, proposed a few algorithms for ant colony optimization (ACO) [1] and particle swarm optimization (PSO) [2]. The algorithms mostly depend on the behaviours that imitating from the social behaviours of the artificial life, such as ants creeping and birds flocking, and these artificial life search have been conducted for finding the best solution by sharing known knowledge with each other, so that they will gather together the best solution point. However, the negative side of this behaviour is that once a search engine catches a local optimum solution which is good enough, and then the solution affects other search engines to detect the same solution, instead of finding the global optimal solution. In 2005, Ying. *et al*. [3] introduced a new concept, and their idea includes the philosophy of astrophysics to design a novel optimal algorithm. The suggested algorithm is encouraged by a simulation of several asteroids shifting within a universe to search for the body with heaviest mass. By referring to the Einstein's general theory of relativity, the space is curved by the gravitational field. Thus, the asteroid will be capable to speed toward the heavy mass around it by the variations in geometry of space-time. And so the asteroid shall be sling-shot by the heavy mass that attract it, and then keep searching for the other heavy masses within the cosmos. Ying. Et all developed a new algorithm under a very simple concept of the general theory of relativity that keeps the algorithm computationally inexpensive in term of both memory requirement and computational power. The most important characteristic of the algorithm is that the probability of finding the local optimal solution is very small, because the searching engine (asteroids) has a great possibility to be thrown out of the local optimal solution, and typically will never stop searching for the other solution in the entire solution space.

In parliamentary law to prove the robustness and efficiency of the space gravitational Optimization, the proposed algorithm has been used in an application of designing of the PID controllers. Several simulation results obtained by the other optimization techniques are likewise offered for comparison.

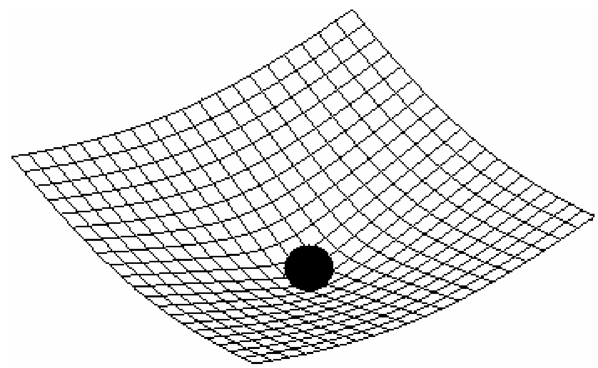

**Figure-1.** The curve of the geometry of space-time. The image is taken from [3].

## 2. EINSTEIN'S GENERAL THEORY OF RELATIVITY

Einstein's general theory of relativity was developed in the early years of the twentieth century, and passed its final shape in 1916. The idea of the Einstein's general theory of relativity was that the inertial and free-falling systems are entirely equivalent. The Einstein's principle of equality declares that the quickening of a free-falling laboratory cancels completely the gravitational force. Then, we can see that the geometry and the gravity have many attributes in common if we illustrate the gravitational field that is as shown in Figure-1. The geometry of space-time is mapped into the curved grid as in Figure-1. The black sphere, in the middle of Figure-1, indicates the heavy mass in the space. Agreeing to the Einstein's general theory of relativity, the geometrical description of the space-time distortion is as follows:

Variation in geometry of spacetime= stress, mass-energy and momentum of source. (1)

The equation is known as Einstein's gravitational field equation. It is similar to the Maxwell's equation, which relates the four independent vectors as well. The detail descriptions of the Einstein's general theory of relativity and astrophysics can be obtained in [5-7].

Now, we recall the Newton's law of gravity, which is as follows:

$$F = \frac{GMm}{\rho^2} = mg \,, \tag{2}$$

where M and m are the two gravitating masses, $\rho$ is the distance between them, G is a constant with a value of $6.67 \times 10^{-11}$ $Nm^2kg^{-2}$, and g is the gravitational acceleration rate charges on me. In this work, we assume the absolute position of M is constant; therefore, the equation (2) can be rewritten as follows:

$$g = \frac{GM}{r^2} \tag{3}$$

By detecting the variation of the equation (3), we shall be able to determine the direction of the gravitational acceleration for the asteroid. The variation of the gravity, that is assumed to be the same as equation (1), is proportional to the inverse square of the variation of the distance between *M* and *m*.

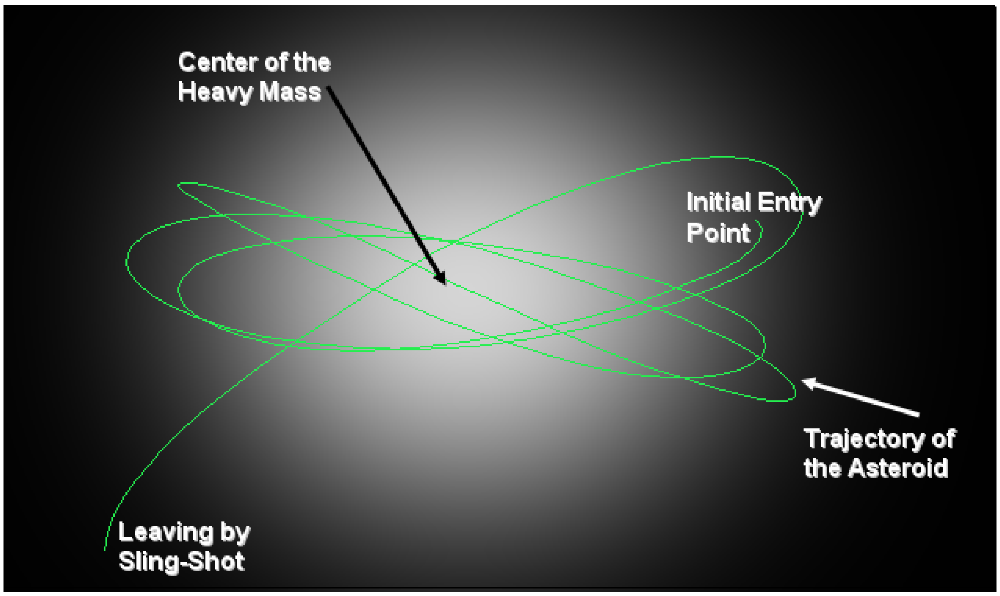


**Figure-2.** Image of the trajectory of an asteroid sling-shot by a heavy mass. The image is taken from [3].

It is extremely improbable that an asteroid makes a motion along the orbiting trajectory of a heavy mass in the world. Thus, an asteroid is affected by the gravitational force of a heavy mass into two potential ways: One, the asteroid might rotate the heavy mass for several circles, and then it might be sling-shot out of the system by the gravity of the heavy mass; the other result is that the asteroid couldn't escape from the heavy mass, and finally crashes on the heavy mass. Even so, in this study, we feign that the actual body of the heavy mass does not physically exist. Therefore, when the asteroid is closed up towards the centre of the heavy mass, the kinetic energy of the asteroid shall be significantly increased by the gravity of the heavy mass, and also provides enough speed for the asteroid to directly sling-shot out of the gravitational field of the heavy mass, as shown in Figure-2. See for more information [4, 5, 6].

## 3. PROPOSED ALGORITHM

In 2005, Ying. et all proposed a new algorithm that based on the gravitational effect between asteroids. The idea is that according to the Newton's gravity of law, strength of gravity existing between two standard mass with standard separation, and the strength of gravity is the same throughout the universe at all time. Therefore, it is reasonable for the gravitational effect between asteroids to join following equations

$$ax_n = G.\{[f(x_n, y_n) - f(x_n + r_d, y_n)] + [f(x_n - r_d, y_n) - f(x_n, y_n)]\} + (\alpha.x_c)/r_n^2 \tag{1}$$

$$ay_n = G.\{[f(x_n, y_n) - f(x_n, y_n + r_d)] + [f(x_n, y_n - r_d) - f(x_n, y_n)]\} + (\alpha.y_c)/r_n^2 \tag{2}$$

where $x_c$ and $y_c$ are the coordinates of the center of mass of all asteroids, which can be simply obtained by the following equations.

$$x_c = \frac{\left(\sum_n x_n\right)}{n} \text{ and } y_c = \frac{\left(\sum_n y_n\right)}{n},$$

where $\alpha$ is a constant that determine the influence of the gravitational effect between all asteroids, $r_n$ is the distance between asteroid n and center of mass of all asteroids. $ax_n$ and $ay_n$ are the acceleration rate on x axis and y axis of asteroid n, respectively. $f(x_n, y_n)$ is the cost function that used to evaluate the goodness of the solution contains by the asteroid n. For details of the algorithm can be seen in [3].

**4. NUMERICAL EXPERIMENTS**

In this paper, we have tested the algorithm proposed by [3]. We considered the test problem that has a complex structure. The test problem is as follows:

$$\min f(x_1, x_2, x_3) \equiv \left(x_1^2 + x_2^2 + x_3^2 - 1\right)x_1$$

Subject to $x_1 \leq 50$, $x_2 \leq 50$, and $x_3 \leq 50$.

We conducted a numerical experiment by using MATLAB, and our obtained results are shown in Figure-4. The test problem is a computationally expensive problem, however, we obtained evenly distributed points for both convex and concave case, and this shown the advantage of the algorithm proposed by [3].

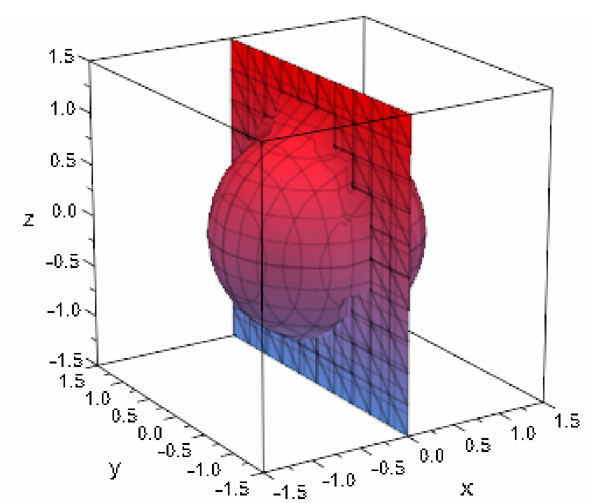


**Figure-3.** Demonstrate the objective function of the problem.

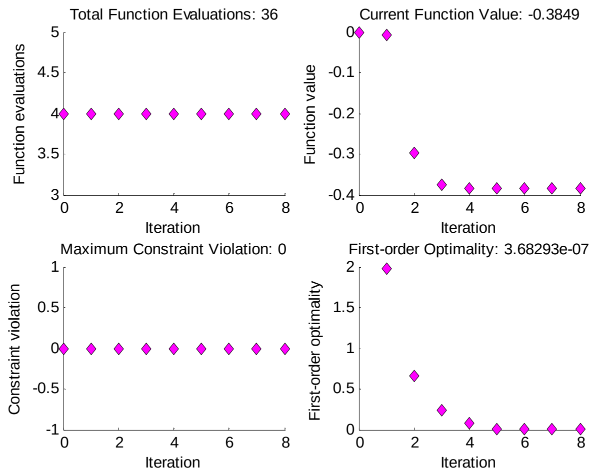


**Figure-4.** Demonstrate the results obtained by the algorithm.

**REFERENCES**

[1] Dorigo M. and Di Caro G. 1999. Ant colony optimization: a new meta-heuristic. Proceedings of the 1999 Congress on Evolutionary Computation. 2: 1477-1484.

[2] Kennedy J. and Eberhart R. 1995. Particle swarm optimization. Proceedings of IEEE International Conference on Neural Networks. 4: 1942-1948.

[3] Hsiao Y., Chuang C., Jiang J. and Chien C. 2005. A Novel Optimization Algorithm: Space Gravitational Optimization. In: Proc. of 2005 IEEE International Conference on Systems, Man, and Cybernetics. 3: 2323-2328.

[4] P. C. W. Davies. 1980. The search for gravity waves, Cambridge University Press: Cambridge.

[5] E. Harrison 2000. Cosmology: the science of the universe, Cambridge University Press: Cambridge.

[6] M. Harwit. 1998. Astrophysical concepts, Spriner: New York, USA.