International Journal of Computer Science and Informatics

Volume 1 | Issue 2 Article 5

October 2011

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Devi, Suprava and Panigrahi, Sunil Kumar (2011) "Intelligent Decision Making Using Particle Swarm Optimization for Optimizing Product-Mix Model," *International Journal of Computer Science and Informatics*: Vol. 1 : Iss. 2 , Article 5.
DOI: 10.47893/IJCSI.2011.1018
Available at: https://www.interscience.in/ijcsi/vol1/iss2/5

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Intelligent Decision Making Using Particle Swarm Optimization for Optimizing Product-Mix Model

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Abstract

The development and deployment of managerial decision support system represents an emerging trend in the business and organizational field in which the increased application of Decision Support Systems (DSS) can be compiling by Intelligent Systems (IS). Decision Support Systems (DSS) are a specific class of computerized information system that supports business and organizational decision-making activities. A properly designed DSS is an interactive software-based system intended to help decision makers compile useful information from raw data, documents, personal knowledge, and/or business models to identify and solve problems and make decisions. Competitive business pressures and a desire to leverage existing information technology investments have led many firms to explore the benefits of intelligent data management solutions such as Particle Swarm Optimization (PSO). This study proposes a new PSO (SPSO)-model based on product mix model for optimizing Constraint values as well as objective function. The formulations of the objective function for the minimization problem. This technology is designed to help businesses to finding multi objective functions, which can help to understand the purchasing behavior of their key customers, detect likely credit card or insurance claim fraud, predict probable changes in financial markets, etc.

Keywords: **Linear problem, Intelligent System, particle swarm optimization, simplex method**

1. Introduction

Organizations generate and collect large volumes of data, which they use in daily operations. Yet despite this wealth of data, many organizations have been unable to fully capitalize on its value because information implicit in the data is not easy to distinguish. However, to compete effectively today, taking advantage of high-return opportunities in a timely fashion, decision-makers must be able to identify and utilize the information. These requirements imply that an intelligent system must interact with a data warehouse and must interface with decision support systems (DSS), which are used by decision-makers in their daily activities [1].

There is a substantial amount of empirical evidence that human intuitive judgment and decision-making can be far from optimal, and it deteriorates even further with complexity and stress. Because in many situations the quality of decisions is important, aiding the deficiencies of human judgment and decision-making has been a major focus of science throughout history. Disciplines such as statistics, economics, and operations research developed various methods for making rational choices. More recently, these methods, often enhanced by a variety of techniques originating from information science, cognitive psychology, and artificial intelligence, has been implemented in the form of computer programs as integrated computing environments for complex decision making. Such environments are often given the common name of decision support systems (DSS).

An intelligent technology is the duplication of human thought process by machine. It learning from experience, interpreting ambiguities, rapid response to varying situations, applying reasoning to problem-solving and manipulating by applying knowledge, thinking and reasoning [1]. Different from traditional optimization technique, evolutionary computation techniques work on a population of potential solutions (points) of the search space. The most commonly used population-based evolutionary computation techniques is **Particle Swarm Optimization (PSO).**

The success of management depends on execution of managerial functions and all managerial functions revolve around decision-making and the manager is a decision maker. Financial decision of a company is very complex and risk problem. Due to the constrained nature of the problem, this paper is looking for a new solution that improves the robustness against existing decision with high effectiveness [1]. The present article proposes a novel strategy for the proper choice of the PSO constants based on the simplex method. In this paper we also presents the comparison and

the relative performance of Traditional Method with intelligent computing techniques like **Particle Swarm Optimization** (PSO) through which a decision maker can enhance decision making, and asses the benefits of variety of intelligent computing techniques. The objective of this paper is to determine the efficiency and accuracy of PSO method for the financial decision of any company.

2. Particle Swarm Optimization

A Swarm can be defined as population of interacting elements (particles) that are able to optimize some global objective through collaborative search of space. It is initialized with a group of random particles and then searches for optima by updating generations. At each step, each particle keeps track of the best solution that it has achieved so far and keeps also track of the overall best value that is obtained thus far by all particles in the population. The nature of interactive elements depends on the problem domain. If the search space is an n-dimensional space, the i^{th} particle of the swarm may be represented by an n-dimensional vector $X_i = (x_{i1}, x_{i2},...,x_{in})$. The velocity of this particle can be represented by another n-dimensional vector $Vi = (v_{i1}, v_{i2},\ldots,v_{in})$. The fitness of each particle can be evaluated according to the objective function of optimization problem. The best previously visited position of the particle i is noted as its individual best position $pbest_i = (p_{i1}, p_{i2},\ldots,p_{in})$. The best position of the swarm is noted as the global best position $gbest_i = (g_1, g_2,\ldots,g_n)$. At each step, the velocity of each particle and its new position will be re-estimated according to the following two equations:

$$V_i^{k+1} = \omega V_i^k + c_1 r_1 (pbest_i^k - X_i^k) + c_2 r_2 (gbest^k - X_i^k) \quad (1)$$

$$X_i^{k+1} = X_i^k + V_i^k \quad (2)$$

where, ω is called the inertia weight that controls the impact of previous velocity of particle on its current one. r_1 and r_2 are independently uniformly distributed random variables in the range [0,1]. $C_1$and C_2 are positive constant parameters called acceleration coefficients which control the maximum step size and *K* denotes evolutionary iterations. In PSO, equation (1) is used to calculate the new velocity according to its previous velocity and to the distance of its current position from both its own best historical position and the best position of the entire population. The particle flies toward a new position according to equation (2). The PSO algorithm is terminated with a maximal number of generations or the best particle position of the entire swarm cannot be improved further after a sufficiently large number of generations. Figure 1 shows the concept of modification of searching points in PSO [12], [13], [14], [15], [16], [19].

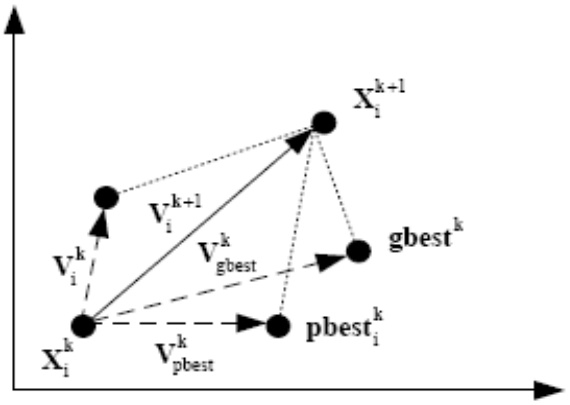


Fig. 1 The concept of modifications of Searching points.

A pseudocode of PSO algorithm is given below,

```
// Initialization
For each particle i
Randomly initialize X_i, V_i for particle i
End For
// Optimization
Do
    For each particle i
        Call calculate_fitness_value
        If current_fitness_value is better than
                    previous_best_fitness_value ( p_i)
    Then
        Current_fitness_value of particle i becomes p_i
     End If
  End For
  Call find_global_best_fitness
  For each particle i
          Call calculate_ V_i   based on eq. (.2)
          Call calculate_ X_i   based on eq.  (.3)
  End For
While MAX_iterations or min_error_criteria is not attained
```

The flow diagram of PSO algorithm is presented in figure 2.

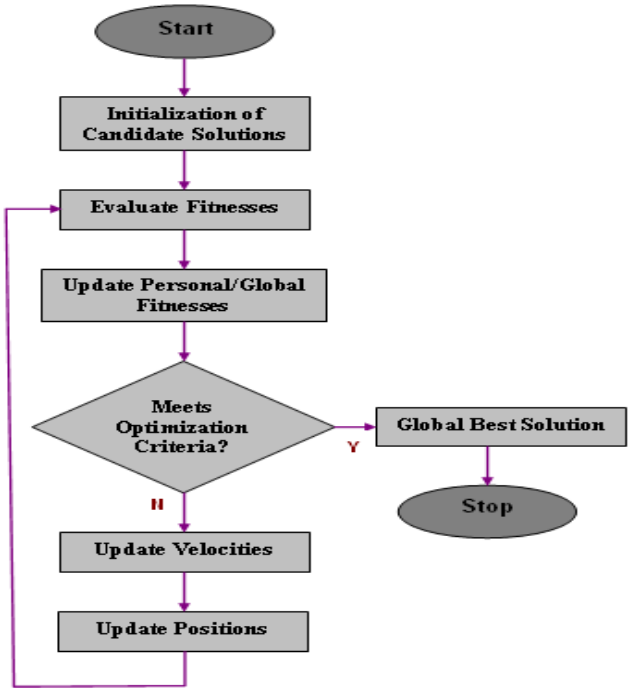


Fig. 2 A simple flow diagram of PSO algorithm.

3. Traditional Method

Applying some well-defined mathematical algorithm known as optimization technique in which the decision theory is based on the assumptions of rational decision makers, whose objective is to optimize the attainment of goals? A well-known Optimization method is linear programming [3] [4].

3.1 Linear Programming

A linear programming is the most commonly applied form of constrained optimization. It may be defined as the problem of maximizing or minimizing a linear function subject to linear constraints. The constraints may be equalities or inequalities. The main components of linear programming problem are decision variable, variable bounds, constraints and objective functions [2] [3] [4].

Example: Product Mix Linear Programming Model [2].

Goal: Maximize Total Profit / Month

Decision variables: $X_1$and X_2

Uncontrollable variables and parameters:

Market requirements: $X_1>=0$; $X_2>=0$

Profit contribution of each X_1 is 3 and X_2 is 2

Result variable: Profit=$3X_1+2X_2$

Constraints:

$X_1+X_2 <= 4$

$X_1-X_2 <= 2$

4. Analysis & Discussion

The key element of an optimization problem is the definition of a profit and cost function. This function is a mathematical function which represents the objectives of the expected solution. The goal of the optimization is usually to find the minima or the maxima of this function. Sometimes, the relationships among the objectives of the optimization problem are so complex that the profit and cost function cannot be defined, or even there is no point in defining a quantitative function (e.g. when the goal is to optimize the quality of a product when the quality is determined by human taste). In this kind of situation, it is very difficult to apply traditional optimization algorithms.

In this section a number of experiments are carried out which outlines the effectiveness of the algorithm described above. The purpose of these experiments is to compare the performance of Simplex Method approach with Particle Swarm Optimization approach for the Product Mix Linear Programming Model. The experiments were conducted on 'Mat lab' and 'c' programming tool. Experimental results obtained from these algorithms were generated with 500 iteration per data point e.g. 40 different populations were created for all the algorithms and each algorithm was run 30 independent runs per data. The best result for each data was produce data point. For each algorithm there are number of different parameters, which need to varied to "fine-tune" the optimization process. Below we have given two comparison graphs for objective values and fitness values for the respective table 1 and table 2.

4.1 Traditional Procedure

It is a scientific approach to automate managerial decision making and it consists of steps i.e. Define the problem, Classify the problem into a standard category, Construct a mathematical model, Find and evaluate potential solutions to model, Choose and recommend a solution to problem [3] [4].

There are several types of traditional methods, i.e. Simplex Method, Dual Method, etc. We follow the simplex method for the above product mix model and the Solution is found as $X_1 = 3$ and $X_2 = 1$, Profit=Rs 11 after 10 to 12 generations.

Table 1: Objective values after 120 generation

Generations	*Traditional LP*	
	X_1	X_2
10	3	1
20	3	1
30	3	1
40	3	1
50	3	1
60	3	1

70	3	1
80	3	1
90	3	1
100	3	1
110	3	1
120	3	1

4.2 Product-Mix Model Using PSO

For the above linear programming model the Particle swarm optimization was set to,

Population size = 40 Maximum iteration = 500

Max Weight = 0.4 Min Weight = 0.9(Decreasing order)

C_1 & C_2 = 1.4 Dimension = 2

Velocity = 0 to 10(increasing order)

Agent initialization between 0 & 1

Fitness Function is, $3X_1 + 2X_2$ in maximization,

$X_1 + X_2 <= 4$

$X_1 - X_2 <= 2$, $X_1, X_2 >= 0$

Weight = Wmax-((Wmax-Wmin)/max. iter) × iter

Velocity = Vmin + (Vmax-Vmin) × Random (pop, dim)

where Vmin=0 & Vmax=10

Table 2: Objective values after 120 generation

Generations	*PSO*	
	X_1	X_2
10	2.9593	1.0149
20	2.9975	1.0025
30	2.9999	1
40	3	1
50	3	1
60	3	1
70	3	1
80	3	1
90	3	1
100	3	1
110	3	1
120	3	1

4.3 Result Analysis

Table 3 and Table 4 summarize the empirical results of the LP Model and Proposed PSO Model on optimization of the Product Mix Problem for fitness value and maximization of profit respectively. The result by the test dataset show that the accuracy and multi-objective resultant of the PSO model is much better than obtained from the LP Simplex model and figure 4 and 5 are the graphically representation of fitness value and optimization value respectively.

Table 3: Fitness values after 120 generation

Generations	*Traditional LP*		*PSO*	
	X_1	X_2	X_1	X_2
10	3	1	2.9593	1.0149
20	3	1	2.9975	1.0025
30	3	1	2.9999	1
40	3	1	3	1
50	3	1	3	1
60	3	1	3	1
70	3	1	3	1
80	3	1	3	1
90	3	1	3	1
100	3	1	3	1
110	3	1	3	1
120	3	1	3	1

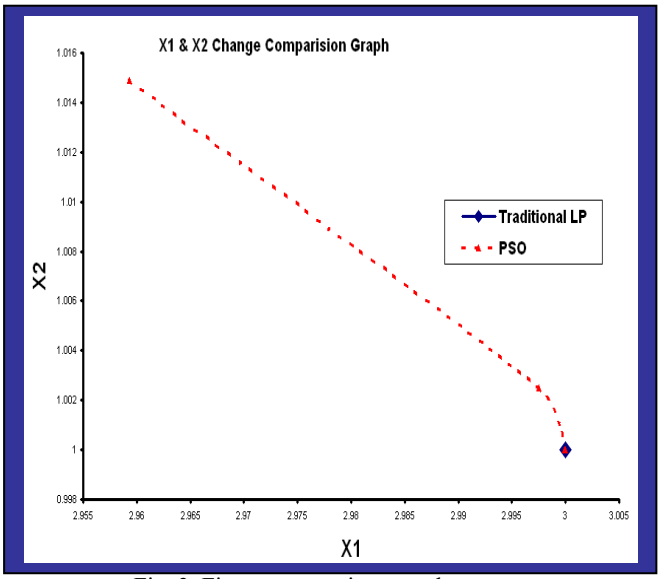
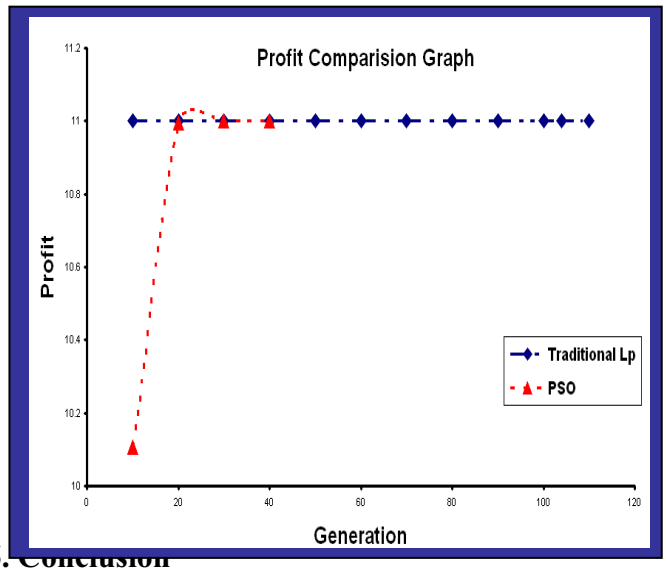


Fig. 3 Fitness comparison graph.

Table 4: Objective values after 120 generation



Generations	*Traditional LP*	*PSO*
10	11	10.1077
20	11	10.9965
30	11	10.9997
40	11	11
50	11	11
60	11	11
70	11	11
80	11	11
90	11	11
100	11	11
110	11	11
120	11	11

5. Conclusion

In some cases, achievement of optimization problems can not be defined in quantitative way. In this kind of situation, it is very difficult to apply traditional and common optimization methods. But PSO may be a good approach. This paper presented a new approach for the product mix linear programming model with simplified & standard algorithm to optimize combinatorial problem. All the algorithms are based on search technique to further improve individual's fitness that may keep high population, diversity and reduce the likelihood premature convergence. Our objective is to determine the performance of particle swarm optimization algorithm in comparison with simplex method for the financial decisions. It seems that the proposed new comprehensive optimization algorithm may be an efficient system in financial analysis.

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