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The Optimal Portfolio Based on the Bat Algorithm Research

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Abstract: *The optimal portfolio model in recent years become a hot research topic in the field of economy, as the scholars of the classical markowitz model, put forward the optimization model is closer to reality and more complex, modeling is not difficult, difficult is how to solve the problem. Bat Algorithm (Bat Algorithm, BA) is a kind of simulation by Yang Bat echolocation behavior of new type of intelligent optimization Algorithm is proposed. The Algorithm gradually aroused people's great attention, and greater success in terms of application. This article will use the bat algorithm to solve the problem, the optimal portfolio for the optimal portfolio model is difficult to solve the general problem, manifests the bat algorithm in solving the optimization model of the role of.*

Keywords : *The optimal portfolio; The bat algorithm; Variance; Multi-objective programming*

I INTRODUCTION

As is known to all, the financial investment is not a crude words, it has gradually into our study, work and life, we are also gradually will invest as a part of our lives, whether we are office workers, migrant workers or big boss, will be conscious of the unconscious to touch this thing.

Now, however, the social rapid development, investment varieties and species are rich and colorful, have divided according to the sort of investment without risk investment and investment risks, according to the investment income, or risk division also has a lot of projects for us to choose, investment project is different, different times, have to withstand risks and the resulting revenue is different, so, now the most important is how to rationally, correct, reasonable and accurate.

Fast growth, investment in the classification of the lot, that we have been able to consciously choose a variety of investment projects, according to the different emphasis on mutual combination, to achieve the best yield, and the least risk, however, profit and risk coexist, in general, the higher the income, the higher the risk, income is general, have to bear the risk is very few, so, how to select the optimal portfolio effectively is what we want to solve the problem.

In this paper to select the optimal portfolio, based on the bat algorithm, establish a reasonable model, efficient searching for different capital proportion of investment projects, in order to achieve maximum yields, as well as the minimum risk coefficient.

1.1 Literature review

On the optimal portfolio, there are many scholars have carried on the thorough research. Shi-qing Miao [2] *(2009) based on intelligent algorithm is studied the portfolio optimization model, the integrated application of value at risk theory and optimization theory, the study of complex and changeable investment decision problems in financial markets, established some portfolio research model based on different risk measures, and for the design of the proposed model to solve the effective feasible intelligent algorithm. Chuan-ming Ding* [3] *, Jie-zhong Zou* [4] *(2002) studied in complete financial markets, investors, the optimal combination of the stochastic model,*

the model parameters for the constant coefficient, the utility function for $(0,T], B[0,T])$ *the bounded measurable function on the circumstances, it is concluded that the maximum utility function is a stochastic control problem is the smooth solution of the corresponding HJB equation, proved to be the optimal strategy, and feedback form the optimal portfolio strategy is presented. Jian-ying Xu* [5] *(2009), from the perspective of the status quo and characteristics of online keyword advertising, introduces the main three online keyword advertising providers, analyzes the importance of investment allocation between different platforms and the research significance, combining the method of bayesian networks for three search engine platform set up separate yield prediction model, and is widely used in the financial sector is introduced into the Markowitz portfolio theory, put forward under the condition of different number of portfolio optimization model, based on this, also from the view of the enterprise of advertisers set up an integrated management platform, unified the previous research work. Xiao-wei Zhang* [6] *(2008) application of modern portfolio theory to establish insurance company portfolio model, with a planning method to work out the optimal portfolio risk, the insurance company to establish insurance company at the same time the utility function, it is concluded that the insurance company to utility maximization of the optimal portfolio, and finally, the theoretical results compared with insurance company actual portfolio analysis, put forward policy Suggestions. Liang-zhu Fan*[7] *(2005) first introduces the basic concepts of portfolio theory, such as risk, such as income, decentralization, relevant, and gives three main models of portfolio, markowitz model, model of single factor and multi-factor model, secondly the markowitz mean - variance model put forward by the optimization Settings extends to transaction fees and don't allow short-selling situation, when the final practice has proved that using genetic algorithm to solve the portfolio optimization problem is very effective.*

In recent years, our country launched the bat algorithm based on a series of application in all fields. Xiao-hua Sheng[8] *, Chun-ming*[9] *(2000) for the new heuristic intelligent algorithm bat algorithm of the limitation of discrete production scheduling problem, use the bat algorithm recoding and initialization approach to solving discrete production scheduling problem, based on the classical scheduling benchmark data to test, and compared to more mature standard particle swarm optimization (pso) algorithm, the results show that the bat algorithm in solving the problem of discrete production scheduling has better optimization performance, bat is verified the feasibility and effectiveness of the algorithm to solve the discrete problem. Zhi-yong Li.*[10] *, Liang Ma*[11] *, Hui-zhen Zhang*[12] *(2000) study the bat algorithm in the application of multiobjective multiple choice knapsack problem, in view of the traditional multi-objective multiple choice knapsack optimization algorithm due to the computational complexity is very high, it is difficult to obtain satisfactory solutions for problems such as, on the basis of the bat algorithm, an improved bat algorithm used for multi target multiple choice knapsack problem, and algorithm design, first introduced the inertial factor effect on the speed of the bat, redefined the update equations of the speed of the bat, is used to improve the convergence speed of the algorithm, and then gives the bat update the rules of individuals and groups, guide the bats fly to Pareto, finally the simulation results show that compared with particle swarm optimization (pso) algorithm, the bat algorithm can find the same number of faster Pareto, manifests the bat algorithm to solve the problem and the feasibility and effectiveness of the bat algorithm performance superiority, expand the application field of the bat algorithm.*

1.2 The optimal portfolio

Portfolio, which is held by the investors or financial institutions of stocks, bonds, derivatives and other collections. The purpose of the portfolio is to spread risk.[13] *Alleged portfolio theory, it is a combination of several different types of securities portfolio, its earnings are weighted average of these securities gains, however, its risk is not these securities risk weighted average of the risk, so the portfolio can help reduce the systemic risk.*[14]

Based on the principle of diversification, the need to diversify into different capital investment projects; On specific investment projects, but also need the assets as diversified distribution, make the investment proportion. Bear in mind that any optimal portfolio, must be spread risk. [13] *Your income is more and more long, will be in the hands of funds dispersed in different fields is absolutely the right thing to do.*

The task of this paper is required to establish an optimal portfolio model, to "profit maximization".

II. THE BAT ALGORITHM

Bat algorithm that is based on micro bats (microbats) echolocation, the basis of different pulse emissivity and loudness.

Bat algorithm of the basic definition, the echo-location in bats is ideal, can be summarized as follows:

Each virtual bats have random speed of v_i *in position* x_i *(solving), at the same time the bat with different frequency or wavelength, loudness,* A_i *and* r *pulse firing rate. Bats hunting and found its prey, it changes, loudness, and emissivity of the pulse frequency, the choice of optimal solution, until the target to stop or conditions are met. This is essentially a tuning technique was used to control the dynamic behavior of the bat group, balance adjustment algorithm related parameters, in order to obtain the bat algorithm of the optimal.*

According to Yang (2010),The new solution speed x_i^t *and* v_i^t *The update equation:*

$$f_i = f_{\min} + (f_{\max} - f_{\min})\beta ,$$

$$v_i^t = v_i^t + \left(x_i^{t-1} - x_*\right) f_i ,$$

$$x_i^t = x_i^{t-1} + v_i^t ,$$

Among them, the number is evenly distributed.

x_* *is now to find the optimal solution.*

A *and* r *should be in the iterative transformation:*

$$A_i^{t+1} = \alpha A_i^t ,$$

$$r_i^{t+1} = r_i^0 [1 - \exp(-\gamma t)] ,$$

Among them, $0 < \alpha < 1$ *and* $\gamma > 0$ *that are constant.*

III. THE OPTIMAL PORTFOLIO BASED ON THE BAT ALGORITHM RESEARCH

3.1 symbolic description

m *says number for venture capital projects*

n *says data for risk investment project of the month*

x_0 *says the proportion of funds for risk-free investment projects*

x_i *says to the first item has the proportion of funds risk investment projects*

y_{0j} *is expressed as risk-free investment funds yield in the* j *months*

y_{ij} *says as the first* i *has a risk investment in the first* j *months return on capital*

$\bar{y}_0$ *is expressed as a risk-free investment investment projects in* j *months average yield*

$\bar{y}_i$ *is expressed as the first* i *a venture capital investment projects in* j *months average yield*

z_0 *is expressed as risk-free investment project risk coefficient*

z_i *says as the* i *has the risk coefficient of risk investment projects*

a *says total net benefits for the portfolio investment income*
b *says to existing total portfolio risk*

3.2 data processing

(1) data into

Because there was no risk investment risk coefficient is 0, so might as well set investment risk-free investment projects of capital ratio is x_0, i *have set up investment risk investment projects of capital ratio is* x_i, *might as well set a total of* m *risk investment project, so the value of* x_i, i *to* $1,2,\cdots,m$.

Same as above, also might as well set j *risk-free investment in the first months of return on capital is* y_{0j}, *set up the first* i *a risky investment projects in the first* j *months of capital return of* y_{ij}, y_{ij} *in* i *for the types of values, given the* $1,2,\cdots,m$, y_{ij} j *values for* $1,2,\cdots,n$.

(2) data correlation

For $x_0, x_1, x_2, \cdots, x_m$, x_0 *to the proportion of funds investment risk-free investment projects,*

$x_1, x_2, \cdots, x_m$ *said as the first* i *investment proportion of funds in risky investment project, so we can draw the following formula:*

$$0 \le x_i \le 1$$

(Including $i = 0,1,2,\cdots,m$ *)*

$$x_0 + x_1 + x_2 + \cdots + x_m = 1 (\sum_{i=1}^{m+1} x_i = 1)$$

(3) the yield data processing

According to different risk investment projects, and by the corresponding risk coefficient is not necessarily the same, so might as well put the first z_i *of risky investment project investment risk coefficient for* y_i, *here, because every* x_i *has a* z_i *counterpart, so the values for* i $1,2,\cdots,m$. *(because there was no risk investment*

risk coefficient is zero, in order to later forms of calculation can be unified, might as well also set a risk-free investment risk coefficient for the z_0, $z_0 = 0$*), for the determination of numerical* z_i $(i = 1,2,\cdots,m)$*, can adopt the form of analog variance, first using* i *a risky investment projects in the first* j *yields* y_{ij} $(i = 1,2,\cdots,m$, $j = 1,2,\cdots,n)$ *months of funds, and given the first* i *a venture capital investment projects in* j *months average yield of* $\bar{y}_i$, $\bar{y}_i$ *'s expression is:*

$$\bar{y}_i = \frac{y_{i1} + y_{i2} + \cdots + y_{in}}{n}$$

(Including $i = 1,2,\cdots,m$*)*

In addition, when $i = 0$*, namely the investment projects as risk-free investment projects, to remember the risk-free investment projects in the first* j *months funds yields for* y_{0j} $(j = 1,2,\cdots,n)$*, to calculate the average yield of* j *months* $\bar{y}_0$*, the computational expressions of* $\bar{y}_0$ *as follows :*

$$\bar{y}_0 = \frac{y_{01} + y_{02} + \cdots + y_{0n}}{n}$$

For a specific $\bar{y}_1, \bar{y}_2, \cdots, \bar{y}_m$*, can also be given to the corresponding expressions:*

$$\begin{cases} \bar{y}_1 = \dfrac{y_{11} + y_{12} + \cdots + y_{1n}}{n} \\ \bar{y}_2 = \dfrac{y_{21} + y_{22} + \cdots + y_{2n}}{n} \\ \vdots \\ \bar{y}_m = \dfrac{y_{m1} + y_{m2} + \cdots + y_{mn}}{n} \end{cases}$$

Next, using variance principle, there are risks of venture capital project investment item first i *coefficient of* z_i *expression :*

$$z_i = \frac{[(y_{i1} - \bar{y}_i)^2 + (y_{i2} - \bar{y}_i)^2 + \cdots + (y_{in} - \bar{y}_i)^2]}{n}$$

(Including $i = 1,2,\cdots,m$*)*

For a specific $z_1, z_2, \cdots, z_m$*, can also be given to the corresponding expressions:*

$$\begin{cases} z_1 = \dfrac{[(y_{11}-\bar{y}_1)^2+(y_{12}-\bar{y}_1)^2+\cdots+(y_{1n}-\bar{y}_1)^2]}{n} \\ z_2 = \dfrac{[(y_{21}-\bar{y}_2)^2+(y_{22}-\bar{y}_2)^2+\cdots+(y_{2n}-\bar{y}_2)^2]}{n} \\ \vdots \\ z_m = \dfrac{[(y_{m1}-\bar{y}_m)^2+(y_{m2}-\bar{y}_m)^2+\cdots+(y_{mn}-\bar{y}_m)^2]}{n} \end{cases}$$

3.3 model is established in this paper

Sets the total net benefits of portfolio investment income to a , a *and* $x_i\ (i=0,1,2,\cdots,m)$ *and* $\bar{y}_i\ (i=0,1,2,\cdots,m)$ *between calculation formula:*

$$a = x_0\bar{y}_0 + x_1\bar{y}_1 + x_2\bar{y}_2 + \cdots + x_m\bar{y}_m = \sum_{i=1}^{m+1} x_i\bar{y}_i$$

For a *the bigger the better, namely:*

$$\max a$$

Set the total risk for the portfolio investment exist b , b *and correlation between* $x_i\ (i=0,1,2,\cdots,m)$ *and* $z_i\ (i=0,1,2,\cdots,m)$ *:*

$$b = x_0{}^2 z_0 + x_1{}^2 z_1 + x_2{}^2 z_2 + \cdots + x_m{}^2 z_m = \sum_{i=1}^{m+1} x_i{}^2 z_i$$

For b *as small as possible, i.e.,*

$$\min b$$

To calculate when the greater the a , b *more hours investment fund proportion* $x_0, x_1, x_2, \cdots, x_m$.

3.4 study the optimal portfolio model

In order to verify the advantages and disadvantages of the algorithm, we introduce the concrete data, to realize the optimal portfolio model establishment and solving, specific four projects for six months the yield data is as follows:

	The first month	*the second month*	*the third month*	*the fourth month*	*the sixth month*	*the fifth month*
The first item	*10.0*	*10.0*	*10.0*	*10.0*	*10.0*	*10.0*
The second project	*9.5*	*12.0*	*8.0*	*17.0*	*11.0*	*9.5*
The third item	*13.0*	*15.0*	*13.5*	*17.0*	*14.5*	*15.0*
The fourth item	*19.5*	*14.5*	*10.5*	*11.5*	*15.0*	*18.0*

(in %)

Step 1: data translation

$$y_{01}=10.0 \quad y_{02}=10.0 \quad y_{03}=10.0 \quad y_{04}=10.0 \quad y_{05}=10.0 \quad y_{06}=10.0$$

$$y_{11}=9.5 \quad y_{12}=12.0 \quad y_{13}=8.0 \quad y_{14}=17.0 \quad y_{15}=11.0 \quad y_{16}=9.5$$

$$y_{21}=13.0 \quad y_{22}=15.0 \quad y_{23}=13.5 \quad y_{24}=17.0 \quad y_{25}=14.5 \quad y_{26}=15.0$$

$$y_{31}=19.5 \quad y_{32}=14.5 \quad y_{33}=10.5 \quad y_{34}=11.5 \quad y_{35}=15.0 \quad y_{36}=18.0$$

By observation of the data, we can find that the first project for risk-free investment projects, the second, three, four projects for risky investments.

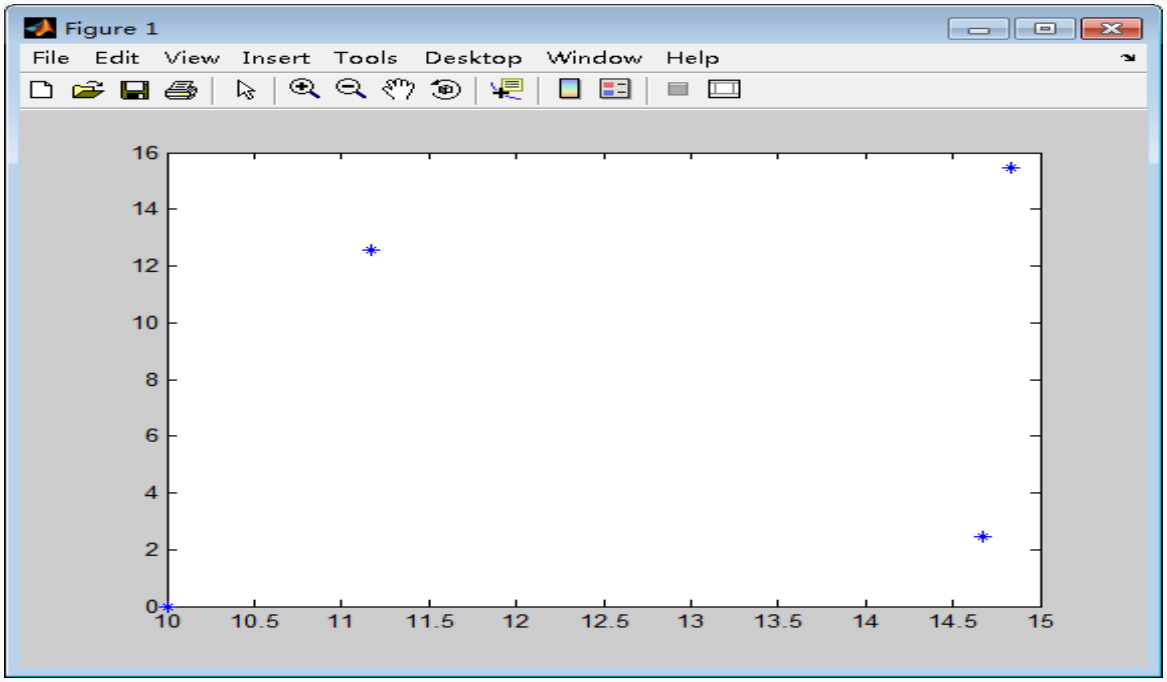
Step 2: basic data preprocessing

$$\bar{y}_0=10.00 \quad \bar{y}_1=11.17 \quad \bar{y}_2=14.67 \quad \bar{y}_3=14.83$$

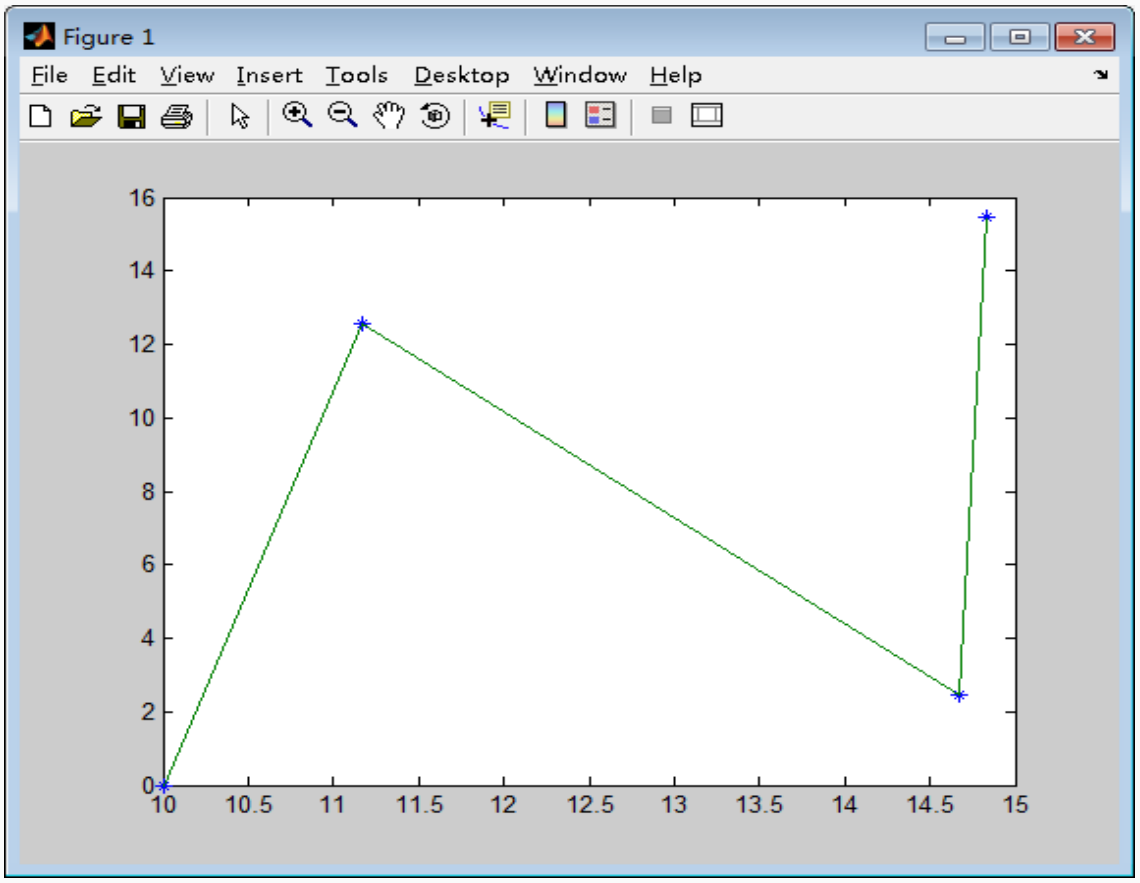
$$z_0=0.0000 \quad z_1=12.5833 \quad z_2=2.4583 \quad z_3=15.4583$$

Step 3: through drawing and data analysis

By operation, drawing, we can get the first i *investment investment projects in* j *months average yield of* $\bar{y}_i \ (i=0,1,2,3)$ *section* i *and investment has a risk investment project risk coefficient of* $z_i \ (i=0,1,2,3)$ *intuitive relationship as shown in the figure below:*



Second, we can also use the line chart more clearly show the first i *investment projects of investment in* j *months average yield of* $\bar{y}_i$ *section* i *and investment has a risk investment projects, the relationship between the risk coefficient of* z_i *specific as shown in the figure below:*



From above, we may direct observations, the greater the income, the higher the risk. However, different investment returns and risk of function is not entirely a function, more or less will have certain amplitude fluctuations, so, we can according to this feature, using the definition and nature of the bat algorithm, to calculate the optimum operation of the portfolio.

Step 4: based on the bat algorithm to calculate

Through calculation of the bat algorithm further, we may safely draw it is concluded that the optimal portfolio model based on the bat algorithm, namely the investment proportion of funds of the project x_1, x_2, x_3, x_4 *:*

$$x_0 = 0.25 \qquad x_1 = 0.30 \qquad x_2 = 0.10 \qquad x_3 = 0.35$$

Step 5: the total earnings

Based on previous funds based on the bat algorithm calculate portfolio proportion, calculate the total net benefits for its portfolio income $a = 12.51$.

Step 6: the total risk is calculated

Based on previous funds based on the bat algorithm calculate portfolio proportion, calculate the total risk of portfolio investment $b = 3.0507$.

IV. SUMMARY

Based on study of portfolio bat algorithm, we take the comprehensive analysis on the nature of the project at different time points to draw the proportion of the investment projects in capital.

First of all, we will be modeled the data collected, in order to accurately the data and model is very good, and not cause not form a complete set and as a result of the data is not accurate. Among them, in order to make the model more representative, we let the data is general, respectively adopt a risk-free investment projects, with

three risky investment projects, a total of four projects, portfolio selection within six months of return on capital. Secondly, data preprocessing, we use average algorithm, return on capital in different period to determine the overall net benefits of the investment project, applying the idea of variance to capital yield per month to uniform the total risk.

We use a given beforehand good portfolio model based on the bat algorithm, the data in, get the optimal portfolio based on the bat algorithm, namely the different investment projects by the effort and money accounted for the proportion of the overall, and carries on the analysis, the feasibility and necessity of the results.

Judging from the results of empirical study, this model is feasible, we can through the project previous returns to uniform the project overall yield and risk coefficient, through the model, it is concluded that the future of the project investment amount of the percentage of the total, through the deductive reasoning, and carries on the analysis, the research team, the result is ideal, successful based on the idea of the bat algorithm the optimal portfolio based on the bat algorithm is obtained.

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