4.4.3简化模型的求解及结果分析

微粒群算法,又称粒子群优化(particle swarm optimization, PSO)是一类基于群体智能的随机优化算法。是由J. Kennedy和R. C. Eberhart等于1995年开发的一种演化计算技术。现已广泛应用于函数优化、神经网络训练、模式分类、模糊系统控制以及其他遗传算法的应用领域[曾建潮,介婧,崔志华.微粒群算法[M].北京:科学出版社,2004:9- 13]

Particle Swarm Optimization is a [random](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E6%99%BA%E8%83%BD%E7%9A%84%E9%9A%8F%E6%9C%BA%E4%BC%98%E5%8C%96%E7%AE%97%E6%B3%95) [optimization](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E6%99%BA%E8%83%BD%E7%9A%84%E9%9A%8F%E6%9C%BA%E4%BC%98%E5%8C%96%E7%AE%97%E6%B3%95) [algorithm](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E6%99%BA%E8%83%BD%E7%9A%84%E9%9A%8F%E6%9C%BA%E4%BC%98%E5%8C%96%E7%AE%97%E6%B3%95" \t "_blank) based on **swarm intelligence, which** **is ev**[olutionary](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E6%BC%94%E5%8C%96%E8%AE%A1%E7%AE%97%E6%8A%80%E6%9C%AF) computation [technology](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E6%BC%94%E5%8C%96%E8%AE%A1%E7%AE%97%E6%8A%80%E6%9C%AF" \t "_blank)[,](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E6%BC%94%E5%8C%96%E8%AE%A1%E7%AE%97%E6%8A%80%E6%9C%AF" \t "_blank) **developed by** J. Kennedy and R. C. Eberhart **in 1995. Now, it is widely used in function, optimization neural network training and fuzzy control system.**

In the D –dimension search space, a group consists of n particles and i th particle refers to D-[dimensional](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E4%B8%89%E7%BB%B4%E5%90%91%E9%87%8F) [vectors](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E4%B8%89%E7%BB%B4%E5%90%91%E9%87%8F" \t "_blank), $x\_i=(x\_{i**1**},x\_{i**2**},\**cdots**,x\_{iD})^T,i=**1**,**2**,\**cots**,n$. Then we plug x\_i back into a objective function to get its [adaptive](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E9%80%82%E5%BA%94%E5%80%BC" \t "_blank) [value](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E9%80%82%E5%BA%94%E5%80%BC" \t "_blank). By comparing the size of value ,we can measure the strength and weakness.

The flight speed of i th [particle](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E7%B2%92%E5%AD%90) should also be n [dimensional](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E4%B8%89%E7%BB%B4%E5%90%91%E9%87%8F) [vectors](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E4%B8%89%E7%BB%B4%E5%90%91%E9%87%8F):

$$v\_i=(v\_{i**1**},v\_{i**2**},\**cdots**,v\_{iD})^T,i=**1**,**2**,\**cdots**,n$$

But the speed of each dimension is limited the area $[-v\_{max},v\_{max}]$,$v\_{max}$ determines the accuracy between current position and the best position. If $v\_{max}$ is high, the particle may miss the optimal solution, on the contrary, if $v\_{max}$ is too small, the particle will not explore insufficiently so as to be trapped in [local](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%B1%80%E9%83%A8%E6%9C%80%E4%BC%98%E8%A7%A3" \t "_blank) [optima](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%B1%80%E9%83%A8%E6%9C%80%E4%BC%98%E8%A7%A3" \t "_blank)[.](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%B1%80%E9%83%A8%E6%9C%80%E4%BC%98%E8%A7%A3" \t "_blank)

The best position i th particle searched to date is:

$$p\_i=(p\_{i1},p\_{i2},\cdots,p\_{iD})^T,i=1,2,\cdots,n$$

At the n ith iteration, the [optimal](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E6%90%9C%E7%B4%A2%E5%88%B0%E6%9C%80%E4%BC%98%E7%9A%84%E4%BD%8D%E7%BD%AE%E4%B8%BA) [location](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E6%90%9C%E7%B4%A2%E5%88%B0%E6%9C%80%E4%BC%98%E7%9A%84%E4%BD%8D%E7%BD%AE%E4%B8%BA" \t "_blank) the particle swarm searched is:

$$p\_g=(p\_{g1},p\_{g2},\cdots,p\_{gD})^T,g=1,2,\cdots,m$$

Before finding two optimal values, the particle swarm updates speed and position in the following equations;

$$**\begin{*cases*}**

v\_{id}^{k+**1**}=w\**timesv**\_{id}^k+c\_**1**r\_**1**(p\_{id}-x\_{id}^k)+c\_**2**r\_**2**(p\_{gd}-x\_{gd}^k)\\

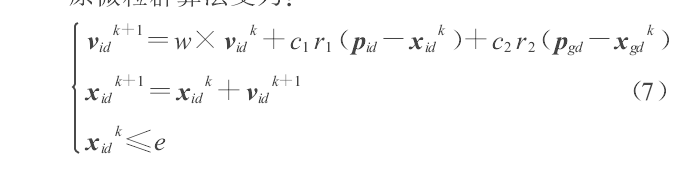
x\_{id}^{k+**1**}=x\_{id}^k+v\_{id}^{k+**1**}

**\end{*cases*}$$**

$i=1,2,\cdots,n$;$d=1,2,\cdots,D$;where $c\_1$ and $c\_2$, are learning factor and **nonnegative number, which belong to $[0,2]$;$r\_1$and $r\_2$** are random numbers between 0 and 1;k refers to **iteration.**

在利用粒子群算法时，为了简化问题，增加对粒子扩散的约束，主观因素引入一个参数e。则粒子群算法变为：

When using particle swarm [algorithm](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E6%99%BA%E8%83%BD%E7%9A%84%E9%9A%8F%E6%9C%BA%E4%BC%98%E5%8C%96%E7%AE%97%E6%B3%95),in order to simplify the problem and increase the confinement on the particle, so we introduce a subjective factor e.



$$**\begin{*cases*}**

v\_{id}^{k+**1**}=w\**times** v\_{id}^k+c\_**1**r\_**1**(p\_{kl}-x\_{kl}^k)+c\_**2**r\_**2**(p\_{gd}-x\_{gl}^k)\\

x\_{id}^{k+**1**}=x\_{id}^k+v\_{id}^{k+**1**}\\

x\_{id}^{k}\**leqslant** e

**\end{*cases*}$$**

参数设定如下：w的取值范围[0.8,1.0]。常数c1,c2取值范围为[0,2]。权重变化速度的界限常数vmax取值范围为[0,1]。 e作为约束条件分别设置为(5,10,15,20,25,30,35,40,45,50),本实验结束条件为最大迭代次数600次。

P[arameters](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%8F%82%E6%95%B0%E8%AE%BE%E5%AE%9A%E5%A6%82%E4%B8%8B) [are](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%8F%82%E6%95%B0%E8%AE%BE%E5%AE%9A%E5%A6%82%E4%B8%8B) [set](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%8F%82%E6%95%B0%E8%AE%BE%E5%AE%9A%E5%A6%82%E4%B8%8B) as follows:

The range of w is 0.8 to1.0;The constant range is 0 to 2.where $v\_max$, is the limit of speed and range from 0 to 1.e as [condition](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E7%BA%A6%E6%9D%9F%E6%9D%A1%E4%BB%B6) [of](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E7%BA%A6%E6%9D%9F%E6%9D%A1%E4%BB%B6) [constraint](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E7%BA%A6%E6%9D%9F%E6%9D%A1%E4%BB%B6) is set $(5,10,15,20,25,30,35,40,45,50)$respectively. The number of iterations just only reach 600 times.

结果分析（待定）

5.灵敏性分析

[Sensitivity](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E7%81%B5%E6%95%8F%E6%80%A7%E5%88%86%E6%9E%90" \t "_blank) [Analysis](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E7%81%B5%E6%95%8F%E6%80%A7%E5%88%86%E6%9E%90" \t "_blank)

5.1 ROI定义式的灵敏性分析

The sensitivity analysis of the definition of ROI

在实际情况中，很多因素我们是有很大不确定性的。我们计算ROI对毕业生的工资（题目所给数据中的一项指标）的灵敏性程度。我们记ROI为r，则得到:

公式

[In](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%9C%A8%E5%AE%9E%E9%99%85%E6%83%85%E5%86%B5%E4%B8%AD" \t "_blank) the [actual](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%9C%A8%E5%AE%9E%E9%99%85%E6%83%85%E5%86%B5%E4%B8%AD) [situation](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%9C%A8%E5%AE%9E%E9%99%85%E6%83%85%E5%86%B5%E4%B8%AD" \t "_blank)[,](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%9C%A8%E5%AE%9E%E9%99%85%E6%83%85%E5%86%B5%E4%B8%AD" \t "_blank)many factors exist [considerable](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%BE%88%E5%A4%A7%E4%B8%8D%E7%A1%AE%E5%AE%9A%E6%80%A7" \t "_blank) [uncertainty](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%BE%88%E5%A4%A7%E4%B8%8D%E7%A1%AE%E5%AE%9A%E6%80%A7" \t "_blank)[.](http://cn.bing.com/dict/clientsearch?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%BE%88%E5%A4%A7%E4%B8%8D%E7%A1%AE%E5%AE%9A%E6%80%A7" \t "_blank) We can get the degree of sensitivity between graduated students’ income and ROI by calculating and define ROI as r, then we get

$$S(r,m)=\frac{dr}{dm}\cdot\frac{m}{r}=1.6$$

由公式可以看出来，工资每增加10%, 学校的ROI提高16%。ROI定义式对工资具有较好的稳定度。因为我们所定义的ROI是毕业学生的社会贡献程度。而工资水平放映了他一定的贡献度。

From the equation ,we can explicitly see that the ROI improves16% when the income increases 10% in per, which reflect the [good](http://cn.bing.com/dict/clientsentence?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%85%B7%E6%9C%89%E7%A8%B3%E5%AE%9A%E5%BA%A6" \t "_blank) [stability](http://cn.bing.com/dict/clientsentence?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%85%B7%E6%9C%89%E7%A8%B3%E5%AE%9A%E5%BA%A6" \t "_blank) of income in terms of

ROI [definition](http://cn.bing.com/dict/clientsentence?mkt=zh-CN&setLang=zh&form=BDVEHC&ClientVer=BDDTV3.5.0.4311&q=%E5%AE%9A%E4%B9%89%E5%BC%8F" \t "_blank), because the ROI we define is the degree of contributions to society for students. Coincidently, wage can show contributions to some extent.

5.2简化模型的灵敏性分析

实际投资中，我们面临的投资学校数目将是巨大的。我们分析投资结果，对可投资数目的灵敏性。通过增加数目，粒子群算法收敛性越来越差。这个情况说明的我们的模型稳定性很差。需要进一步分析约束条件的设定。

6.模型评价

优点

我们对数据分析的较为透彻。

我们将问题分解为几个子问题求解，将问题细化。我们一共建立了三个模型，分别用于求解投资学校、投资金额以及持续时间。模型之间相互联系，共同构成一个整体。

合理提出假设，并初步细化模型。我们首先考虑简化问题，通过提出合理的假设，简化问题的分析。然后逐步去掉假设，建立复杂模型，逼近实际情况。

缺点

定义的ROI考虑不全面。我们参考金融领域对ROI的定义方式。我们只考虑了与ROI最直接相关的因素。所以，对于ROI的定义不够准确，在一定程度上无法反映各个大学真是的回报率。

数据处理主观判断影响较大。通过对题目给的数据以及收集的数据的整理，我们主观舍弃了一些没有价值的指标。使我们最后分析的结果有一定影响。

AHP评价结果受主观因素影响较大，不够准确。AHP的判断矩阵是通过查阅文献资料、询问专家后确定下来的。所以结果受主观因素影响很大。

持续时间估算的不够准确。由于学校不同年份的数据较少，每个学校只有4到5年的数据。根据图像走势作出的判断不够准确。

Future work

完善对ROI的定义。进一步分析数据，找出与ROI呈负相关的因素。建立更能够反映学校回报率的ROI定义。优化投资策略。

结合模糊综合评价，降低AHP的主观性的影响。模糊综合评价更依赖于数据。整合两种评价方法，选取恰当的权值比例。能够有效地减少AHP的主观因素影响。这样可以进一步优化候选名单。

完善动态的多期的投资组合模型。多期多目标动态投资组合模型，考虑情况更加接近实际情况。通过这个模型，可以在统一分析投资资金、投资学校和投资时间的情况下求解各值。我们会继续思考合适的算法。我们尽力将动态多期模型完善并求解出结果。

7.参考文献