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2016 Mathematical Contest in Modeling (MCM/ICM) Summary Sheet

An Investment in Education is an Investment in The Future

Summary

The famous '80-20' rule states that the 80% influence is caused by the 20% for many events. This principle is also suitable for the investment. In order to determine an optimal investment strategy, the problem is divided into three requirements and the Optimal Educational Investment Model is proposed to solve it.

For the first requirement, we gain Prioritized Candidate List through Return on Investment (ROI). To get more complete data, Support Vector Machine (SVM) is used for data processing. Based on Large Margin Nearest Neighbor (LMNN) method and the '80-20' Rule, we can get the weights of "the graduation rate", "Proportion of students' wages over 25000 dollars after 6 years", "The median income after 10 years" and "Repayment rate of 3 years", which are used to calculate the Return Index(RI). We define ROI as RI divided by the corresponding investment. ROI determines the priority of the investment, and thus the Prioritized Candidate List is obtained. The list shows that Southern Virginia University, Southern Wesleyan University and Lakeland Community College are three most worthy investment universities.

For the second requirement, based on the relationship between the amount of investment and RI of each universities, we gain a one year optimal investment strategy. According to the "80-20" rule, we invest only 20% of colleges. In order to ensure the diversity of investment, we set the upper and lower bounds on the proportion of investment funds. To maximize the total RI of each college, we take the limitation of funds as a constraint and build a linear program model. By solving linear programming, we obtain the amount of investment in each college in one year. The result shows we ought to invest 1,040,000 dollars to Southern Virginia University.

For the third requirement, we introduced the elimination mechanism to improve the efficiency of investment funds. After one year investment, the invested universities produce new results. Then, we use the first requirement's method to compute the ROI, make a rank, eliminate the last 5%, and use the second requirement's method to compute the next year's amount of investment. By using the similar method, we can obtain the Prioritized Candidate List of the next 3 years. According to our model, MIT university is not invested in the second year.

In order to further study the problem, combined with Reinforcement Learning, Reinforcement Learning Model is established. Compared with the optimal investment model we analyze their respective advantages and disadvantages. Moreover, sensitivity analysis of the upper and lower bounds on the investment and the elimination rate is discussed.

Keywords: Support Vector Machine, Large Margin Nearest Neighbor, Linear Program, Return on Investment, Reinforcement Learning

Contents

1 Introduction

1.1 Background

The company faced some managerial problems such as high churn rate, job mismatch, low quality employees and so on. Thus, the **Human resource (HR)** management is proposed as a suitable proposal to improve the situation. Human resource management is a function in organizations designed to maximize employee performance in service of an employer's strategic objectives. HR is primarily concerned with the management of people within organizations, focusing on policies and systems.

The hired excellent HR specialists need to achieve the following tasks:

- Design a robust and well-rounded corporate structure, which match the suitable employees to the right position according to their talents and stays stable when people churn
- Arrange the enterprise training and promotion reasonably to provide the elites the chance of ability improving and material prize
- The harmony and stimulating atmosphere is also necessary to cultivate, which fosters the growing of company culture and increasing of the loyalty of the employees.

To meet the above requirements, it is vital to build a Human Capital Network to describe the dynamic process of HR. The network will manage the HR intelligently and automatically to a certain extent and reflect the fluid of people clearly. It may contribute to monitor and control the skilled personnel in order to prevent them from turning over and analyse the corporate profit.

1.2 Problem Restatement and Analysis

Based on the above requirements, the HR managers are to develop a model with bold assumption to reflect the dynamic process of the HR.

2 Assumption

(1) Build the co-author network of the Erdos1 authors and analysis of the characteristics of the network.

(2)

3 Symbol Description

In the section, we use some symbols for constructing the model as follows.

Symbol	Description
σ	The standard deviation
110010101010	binary
F	This is the best beautiful symbol.

P.s:Other symbol instructions will be given in the text.

4 The Influence of Researchers

4.1 Model one:Model abstract

4.1.1 Insert a picture for example

In this section,we will test to insert a picture.

Look at Figure 1

Figure 1: This is a cat.

Figure 2: This is a cat.

Figure 3: This is the back of a human.

4.2 Model two:

4.2.1 Test insert math formulas

In the section, we will insert math formulas.
$\ln(x+1) + \max\{\varepsilon, \theta\}$

$$\exists\, \delta > 0, \quad when \quad |x - x_0| < \delta, \quad s.t.\, |f(x) - f(x_0)| < \varepsilon \tag{1}$$

$$\ln(x+1) + \max\{\varepsilon, \theta\}$$
$$\ln(x+1) + \max\{\varepsilon, \theta\}$$

4.2.2 Test Equations

$$f(x) = \cos x \tag{2}$$
$$f'(x) = -\sin x \tag{3}$$
$$\int_0^x f(y)dy = \sin x \tag{4}$$

4.2.3 Others

$$\begin{aligned} A &= (B + C) + D \\ &= B + (C + D) \end{aligned}$$

OK, let's look at another one.

$$\begin{cases} \dot{x}(t) = A_{ci}x(t) + B_{1ci}w(t) + B_{2ci}u(t) \\ z(t) = C_{ci}x(t) + D_{ci}u(t) \end{cases} \tag{5}$$

$$A = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}.$$

4.3 Result Analysis:

Table 1: Rank of Researcher (Top 10)

Rank	Researcher Name
1	ALON, NOGA M.
2	HARARY, FRANK*
3	GRAHAM, RONALD LEWIS
4	BOLLOBAS, BELA
5	RODL, VOJTECH
6	SOS, VERA TURAN
7	TUZA, ZSOLT
8	FUREDI, ZOLTAN
9	SPENCER, JOEL HAROLD
10	POMERANCE, CARL BERNARD

Table 2: Rank of Researchers' Total Influence (Top 10)

Rank	Researcher Name
1	ALON, NOGA M.
2	GRAHAM, RONALD LEWIS
3	RODL, VOJTECH
4	BOLLOBAS, BELA
5	HARARY, FRANK*
6	FUREDI, ZOLTAN
7	TUZA, ZSOLT
8	SOS, VERA TURAN
9	SPENCER, JOEL HAROLD
10	GYARFAS, ANDRAS

Table 3: Test

No. \ Title	L-Title	R-Title
1	One	First
2	Two	Second
3	Three	Third

5 The Influence of Papers

6 Model Extension

7 Error/Sensitivity Analysis

8 Analysis of The Model

References

[1] Last name, Initials. (year). Title.*The journal name*. Volume(Issue), pages.

[2] Last name, Initials. (year). *Book name*. Address: Publisher.

[3] Last name, Initials. (year). Collection name, *Article name*(pp.pages). Address: Publisher.

[4] Author. Article Title[D]. Address: Saver, year: page numbers.

[5] The site name, Title. The Site Link. Time.

[6] The main responsibility author. Electronic document titles. Electronic literature source[Symbol]. Site Link, Publish or update date / date references.

Appendices

Appendix A First appendix

some text...

Here are simulation programmes we used in our model as follow.

Input matlab source:

```
function [t,seat,aisle]=OI6Sim(n,target,seated)
%
%This is a example of Matlab source code for the model.
%Enjoy yourself.
%
pab=rand(1,n);
for i=1:n
    if pab(i)<0.4
       aisleTime(i)=0;
    else
        aisleTime(i)=trirnd(3.2,7.1,38.7);
    end
end
```

Appendix B Second appendix

some more text

Input C++ source:

```
//============================================================================
// Name        : Sudoku.cpp
// Author      : wzlf11
// Version     : a.0
// Copyright   : Your copyright notice
// Description : Sudoku in C++.
//============================================================================

#include <iostream>
#include <cstdlib>
#include <ctime>

using namespace std;

int table[9][9];

int main() {

    for(int i = 0; i < 9; i++){
        table[0][i] = i + 1;
    }

    srand((unsigned int)time(NULL));

    shuffle((int *)&table[0], 9);

    while(!put_line(1))
```

```
    {
        shuffle((int *)&table[0], 9);
    }

    for(int x = 0; x < 9; x++){
        for(int y = 0; y < 9; y++){
            cout << table[x][y] << " ";
        }

        cout << endl;
    }

    return 0;
}
```