Nonlinear Differential Equation in University Education Information Course Selection System

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Abstract

This paper applies a nonlinear differential equation to the information management system of college course selection. A teaching information management system based on an approximate learning strategy is presented by using statistical linearization technology. An imprecise controller is obtained by numerical simulation of Riccati differential equations with statistical linearization. This kind of Riccati differential equation differs significantly from the ordinary one. Then the system proposes a collaborative filtering method based on nonlinear differentiation based on student feature classification. At last, this paper systematically analyzes the differences between course selection systems, business recommendations, and student attributes—the system experiments on college students’ choice of a learning platform. The study found that the method was correct 34.6% of the time. This system can provide practical guidance for students to choose courses.

Keywords: Course recommendation; Recommendation engine; Nonlinear differential equation; Course selection system; Management information system.

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1 Introduction

With the rapid development of network technology, it is urgent to deal with the network's information overload problem. Users expect to get what they need from a lot of information. The report's producers also expect the information to be used in the vast amount of data. In this context, network technology has developed rapidly from the original classification, search engine, recommendation, and other technologies. Recommendation engine has become the focus of the industry and the industry in recent years. It can effectively interact with the user. Recommendation systems use users' characteristics to "guess" their favorite content and provide corresponding suggestions. The Riccati differential equation method can be used to solve the linear difference method of linear quadratic exponential in the course recommendation system [1]. But in practice, most systems are nonlinear. It isn't straightforward compared to linear difference games. It often needs to solve the nonlinear Hamilton-Jacobi-Isaacs (HJI). The university selection system is the core of resource development. The course selection system is the primary carrier for obtaining course information and independent training plan. A sound course selection system should be simple, easy to use, logical, and balanced teaching resources. Presently, the application of recommendation engines in the field of the university selection system is mainly for book lending and selection [2]. This paper adds "course recommendation" to the existing course selection system and carries out personalized teaching according to the characteristics of students. This is an innovative project.

2 Approximation strategy of nonlinear differential games

The two best approximate solutions of Equation (1) and the fitting degree of the corresponding game are as follows:

\[ \alpha = -G^{-1}\lambda_1^T(\xi y + \xi_1) \]
\[ \beta = E^{-1}\lambda_2^T(\xi y + \xi_1) \]
\[ W(\alpha, \beta) = n^T\xi(0)n + \theta r\{\xi(0)G\} + 2\xi_1^T(0)n + \xi_0(0) \]

(1) (2)

The Riccati differential equations of the positive definite symmetric matrix \( \xi \) are as follows:

\[
\begin{cases}
\dot{\xi} + \xi P + P^T\xi - \xi \lambda_1 G^{-1}\lambda_1^T + \xi \lambda_2 E^{-1}\lambda_2^T S + S = 0 \\
\xi(\theta_h) = \gamma_T
\end{cases}
\]

(3)

The derivative of the vector \( \xi_1 \) and the scalar \( \xi_0 \)

\[
\begin{cases}
\dot{\xi}_1 + \xi_1 P + \xi_1^T h_0 - \xi \lambda_1 G^{-1}\lambda_1^T \xi_1 + \xi \lambda_2 E^{-1}\lambda_2^T \xi_1 = 0 \\
\xi_1(\theta_h) = 0
\end{cases}
\]

(4)

\[
\begin{cases}
\dot{\xi}_0 + 2\xi_0^T h_0 - \xi_0 \lambda_1 G^{-1}\lambda_1^T \xi_1 + \xi_0 \lambda_2 E^{-1}\lambda_2^T \xi_1 + \theta r\{\xi r(\theta)r^T\} = 0 \\
\xi_0(\theta_h) = 0
\end{cases}
\]

(5)

\( P \) and \( h_0 \) conform to the linear equations of statistics.
The values of \( O_1, O_2, \sigma_1 \) and \( \sigma_2 \) here are

\[
\begin{align*}
O_1 &= -G^{-1}A_1^T \xi, \quad \sigma_1 = -G^{-1}A_1^T \xi_1 \\
O_2 &= E^{-1}A_2^T \xi, \quad \sigma_2 = E^{-1}A_2^T \xi_1
\end{align*}
\]  

The stochastic dynamics method is used to verify it in two stages.

1) Construct the Hamilton-Jacoby Isaacs universal function equation \([3]\). Set the hazard function \( h(\theta) \)
at time \( \theta \) to be

\[
F_{\theta}(\alpha, \beta) = y^T (\theta_h) y(\theta_h) + \int_0^\theta (y^T S y + \alpha^T G \alpha - \beta^T E \beta) \, d\tau
\]  

The function is assumed to be Markov. This method depends only on time \( \theta \) and the control vectors \( \alpha(\tau) \) and \( (\theta \leq \tau < \theta_h) \) after the time point, but not on the control vectors before time \( \theta \). Define the minimum and maximum of concerning \( \alpha, \beta \)

\[
M(\alpha, \beta) = \min_{\alpha} \max_{\beta} E[F_{\theta}(\alpha, \beta) \mid X]
\]  

\( X \) is a complete collection of country information. \( X = \{y(\tau) \mid 0 \leq \tau \leq \theta\} \) uses the Ito difference method to find an arbitrary Hamilton-Jacoby Isaacs equation

\[
\begin{align*}
M_\theta + \frac{1}{2} \theta r [M_\gamma r(\theta) r^T] + \min_{\beta} \alpha \max_{\alpha} & \{y^T S y + \alpha^T G \alpha - \beta^T E \beta + \\
M_y^T (h + \lambda \alpha + \lambda_2 \beta) \} = 0
\end{align*}
\]  

\( M_\theta, M_\gamma \) and \( M_y \) are first-order partial and quadratic derivatives of \( M \) concerning time and state \([4]\).

The ending situation is:

\[
M(\theta_h) = y^T (\theta_h) y(\theta_h)
\]  

2) Solve the Hamilton-Jacoby Isaacs pan-function equation

In solving (12), the minimum polarization operation should be performed on the right side of this formula. At this time, this paper obtains the control force of \( \alpha(\theta) \) and \( \beta(\theta) \):
The result of statistical linearization of the nonlinear function \( h \) is replaced by equation (12):

\[
M_\theta + \frac{1}{2} \partial r \{ M_{yy} r \gamma(\theta) r^T \} + \{ y^T S y + \frac{1}{4} M_y^T \lambda_1 G^{-1} \lambda_1^T M_y - \frac{1}{4} M_y^T \lambda_2 E^{-1} \lambda_2^T M_y + M_y^T (h_0 + P y - \frac{1}{2} \lambda_1 G^{-1} \lambda_1^T M_y + \frac{1}{2} \lambda_2 E^{-1} \lambda_2^T M_y) \} = 0
\]

It can be simplified as follows:

\[
M_\theta + \frac{1}{2} \partial r \{ M_{yy} r \gamma(\theta) r^T \} + \left\{ y^T S y - \frac{1}{4} M_y^T \lambda_1 G^{-1} \lambda_1^T M_y + \frac{1}{4} M_y^T \lambda_2 E^{-1} \lambda_2^T M_y + M_y^T h_0 + M_y^T P y = 0
\]

Termination conditions

\[
M(\theta_h) = y^T (\theta_h) y(\theta_h)
\]

In this paper, the characteristics of linear partial differential equations assume that the solution of the Equation is

\[
M = y^T \xi y + 2 \xi_1 y + \xi_0
\]
In this paper, Equation (20) is substituted into Equation (17) to obtain:

\[
M_{\phi} = y^T \dot{\xi}_y + 2 \dot{\xi}_y + \dot{\xi}_0 \\
M_y = 2 \xi y + 2 \xi_1 \\
M_{yy} = 2 \xi
\]  

(20)

After finishing, we can get:

\[
y^T \dot{\xi}_y + 2 \dot{\xi}_y + \xi_0 + \theta r \xi r(\theta) r^T y + \\
\{ y^T S y - (\xi y + \xi_1)^T \lambda_y \lambda_y^{-1} \lambda_0^T (\xi y + \xi_1) + \\
2(\xi y + \xi_1)^T P y + (\xi y + \xi_1)^T \lambda_y E^{-1} \lambda_y^T \} x + \\
(\xi y + \xi_1)^T h_0 = 0
\]  

(21)

This paper obtains an absolute mathematical expectation for the above formula. We have to pay attention to arbitrary properties [5]. If Equation (22) is valid, then the following conditions must be met:

\[
\dot{\xi} + \xi P + P^T \xi - \xi \lambda_y \lambda_y^{-1} \lambda_0^T \xi + \xi \lambda_{y2} E^{-1} \lambda_{y2}^T \xi + \xi P + P^T \xi = 0 \\
\xi \lambda_{y2} E^{-1} \lambda_{y2}^T \xi + S = 0 \\
\dot{\xi}_1 + \xi_1 P + \xi_1 h_0 - \xi \lambda_y \lambda_y^{-1} \lambda_0^T \xi_1 + \\
\xi \lambda_{y2} E^{-1} \lambda_{y2}^T \xi_1 = 0 \\
\dot{\xi}_0 + \xi_0 h_0 + h_0^T \xi_1 - \xi \lambda_y \lambda_y^{-1} \lambda_0^T \xi_1 + \\
\xi \lambda_{y2} E^{-1} \lambda_{y2}^T \xi_1 + \theta r \xi r(\theta) r^T \xi_1 = 0
\]  

(23)

The boundary conditions

\[
\xi(\theta) = \gamma, \quad \xi(\theta) = 0, \quad \xi_0(\theta) = 0
\]  

(24)

In this paper, two optimal strategies are obtained by substituting \( M_y = 2 \xi y + 2 \xi_1 \) into (15):

\[
\alpha = -G^{-1} \lambda_0^T (\xi y + \xi_1) \\
\beta = E^{-1} \lambda_2^T (\xi y + \xi_1)
\]  

(25)

The assumed formal parameters \( O_1, O_2, \sigma_1, \) and \( \sigma_2 \) are derived from the previous control quantities

\[
\begin{cases}
O_1 = -G^{-1} \lambda_0^T \xi, & \sigma_1 = -G^{-1} \lambda_0^T \xi_1 \\
O_2 = E^{-1} \lambda_2^T \xi, & \sigma_2 = E^{-1} \lambda_2^T \xi_1
\end{cases}
\]  

(26)
And the index function is equal to

\[ W(\alpha, \beta) = M(y(0), 0) = n^T \xi(0) + \theta r\{\xi(0)G\} + 2\xi(0)n + \xi_0(0) \]  

(27)

Here \( h(y, \theta) = Ay \) has a random linear system:

\[ \dot{h} = An, P = A, h_0 = \dot{h} - An = 0 \]  

(28)

Then the statistical linearization equation is

\[ \dot{y}(\theta) = Py(\theta) + \lambda_1(\theta)\alpha + \lambda_2(\theta)\beta + r\xi + h_0 = Ay(\theta) + \lambda_1(\theta)\alpha + \lambda_2(\theta)\beta + r\xi \]  

(29)

Because \( h_0 = 0 \) also has to relate the linear relationship between \( M_y \) and the state variable \( y \).

\[ M_y = 2\xi y, \dot{\xi}_1 = 0 \]  

(30)

Substituting this into Theorem 1, we can obtain the following:

\[ \begin{aligned}
\dot{\xi}_0 + \theta r\{\xi r\gamma(\theta)\gamma^T\} &= 0 \\
\xi_0(\theta) &= 0
\end{aligned} \]  

(31)

Through the integral

\[ \xi_0(0) = \int_0^\theta \theta r_{\gamma}r_{\gamma} d\tau \]  

(32)

The final performance indicator value is

\[ W(\alpha, \beta) = n^T \dot{\xi}(0)n + \theta r\{\xi(0)G\} + \int_0^\theta \theta r_{\gamma}r_{\gamma} d\tau \]  

(33)

The above conclusions are consistent with the calculated values of the system of random linear equations. Prove that theory 1 is correct.

3 Analysis and design of university course selection information system structure

3.1 Structure of course selection information system

The system targets students and students. Its users can be divided into three parts: one is the management personnel. Its job is to keep it running [6]. The second is teachers. They belong to the general user. Teachers can add, delete, register, and answer courses online. The third type is mainly students. Students can only select classes and inquire about procedures. Students can use their accounts and password to study online. Students can choose the related courses and operation buttons according to the user's identity. Administrators can manage and maintain the entire software. Teachers can use selection to create new pathways and grade selected projects. Students can choose
elective courses according to their course selection system. Figure 1 shows the business flow chart of the course selection system.

Figure 1. Business flow chart of the course selection system

3.2 Data flow analysis

The design and development of course selection systems inevitably need a lot of data because the ultimate purpose of choosing a learning system is to make the data paperless before the development of the system to the data processing process of a comprehensive analysis. This can make the course selection system development process straightforward and prevent errors due to unreasonable data. The study of the data stream of the course selection system is generated based on the interaction between students and course selection [7]. This paper designs a set of scientific data logic based on information flow and storage. This way, the information flow and maintenance operation in course selection can be ensured. Students choose courses, and teachers can ensure that teaching materials are stored in the database. When TEACHERS grade AND students CHOOSE COURSES, THE DATABASE can transfer the information they need to the relevant users. Figure 2 shows the detailed data flow.
3.3 System architecture design

This course system design is based on B/S architecture. This makes it easy for students and other users to use the course system [8]. Figure 3 shows the system architecture design diagram.

![Diagram](image-url)
1) Presentation layer. The software uses the front-end structure based on Bootstrap and JSP technology. This way, the front interface login window, administrator window, teacher window, and student options window display, and operation. This interactive interface between the user and the course management system [9]. The client can perform various functions such as course selection, course setting, and maintenance management through the browser.

2) Intermediate functional layer. This level is the core part of the course selection system. It is responsible for the needs and processing of students and the access and judgment of background information [10]. Its central role is to store data, invoke data, and process different business logic.

3) Data service layer. This level is responsible for storing and accessing student data, teacher data, course data, and course data. It is the base for course materials.

### 3.4 System module design

The research content of this topic includes four modules: administrator, teacher, student, and independent [11]. The management system is divided into course management and user management. Each unit has a corresponding data display. Its detailed module design is shown in attached Figure 4.

![Figure 4. System module design diagram](image-url)
4 Course recommendation service in the course selection system

The course recommendation engine of this system selects experienced students as the research objects. This paper takes the course selection in the first semester of the 2021-2022 academic year as a case and makes statistics on its accuracy, recall rate, and acceptance rate. The difficulty of implementing this system lies in determining the value of K. K is the number of students close to the target [12]. This article selects 8 to 10 suitable majors for the student. The choice of K is crucial. If the value of K is smaller, the complexity and coverage of the operation will decrease. The accuracy of the recommendation may decrease when K is high. Table 1 shows the experimental results of the stuff algorithm under different K values.

Table 1. Experimental results of the stuff algorithm under different K values

<table>
<thead>
<tr>
<th>K</th>
<th>Accuracy / %</th>
<th>The recall rate / %</th>
<th>Coverage / %</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>17.95</td>
<td>8.78</td>
<td>50.66</td>
</tr>
<tr>
<td>10</td>
<td>26.42</td>
<td>10.28</td>
<td>43.48</td>
</tr>
<tr>
<td>15</td>
<td>34.32</td>
<td>11.44</td>
<td>36.27</td>
</tr>
<tr>
<td>20</td>
<td>36.04</td>
<td>12.14</td>
<td>30.70</td>
</tr>
<tr>
<td>25</td>
<td>36.35</td>
<td>11.51</td>
<td>29.48</td>
</tr>
</tbody>
</table>

Table 1 shows that the correct rate and recovery ratio are not linear. When K is 20, the suggested result is more accurate. The increase in K will make more people choose some popular subjects and reduce the popularity rate.

5 Conclusion

The "course selection" engine designed by this paper is an integral part of the lack of "intelligent campus" and "humanization" education in Chinese universities. In this paper, an optimization method of stochastic nonlinear difference method is derived by using the stochastic dynamics method. This method includes a Riccati differential equation with statistical linearization. Its solution is quite different from the solution of Riccati's Differential Equation. In this paper, using this technology can not only balance the existing teaching resources in the school but also provide the best elective plan for students.

References


