International Journal of Computing Sciences Research (ISSN print: 2546-0552; ISSN online: 2546-115X)
Vol. 9, pp. 3711-3721
doi: 10.25147/ijcsr.2017.001.1.244
https://stepacademic.net

Concept Paper

Academic Recommender System Utilizing a Genetic Algorithm

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Date received: June 16, 2024
Date received in revised form: April 1, 2025
Date accepted: May 12, 2025

Recommended citation:

Dela Cruz, S. M. (2025). Academic recommender system utilizing a genetic algorithm. *International Journal of Computing Sciences Research*, 9, 3711-3721. https://doi.org/10.25147/ijcsr.2017.001.1.244

Abstract

Purpose – The study aims to develop an academic recommender system for various higher education institutions, particularly in Ilocos Norte. A recommendation model will be trained via TensorFlow with the use of various datasets that will be collected from the participating Higher Education Institution (HEI). The system will utilize a genetic algorithm to generate personalized recommendations tailored to the students' profiles. The goal is to assess the performance of the algorithm in giving recommendations to the users, as well as to develop a recommendation system that can be used by the students.

Method – This study will employ a combination of quantitative and qualitative methods. The qualitative method will review the current systems, technologies, and existing methods that are utilized in developing a recommender system, specifically in the field of academe. The quantitative aspect involves data analysis and modeling to create degree program recommendations.

Conclusion – The study focuses on the evaluation of the genetic algorithm in giving recommendations. This will also explore and compare the said algorithm with the existing systems that use other techniques and algorithms. Furthermore, it will lead to the development of an academic recommender system which can be used by the students to make sure that they are on their right path and will also guide them in choosing the right degree that suits their profile.

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Recommendations – This study strongly recommends the adoption of the proposed system in educational sectors. The implementation of the study will help maximize the success rate of students in their academic pursuits as the system will serve as their guide in their academic journey.

Practical Implications – The academic recommender system will benefit not only the students and the higher education involved but also the future researchers who will conduct a similar study, as it will contribute valuable insight into the field of recommender systems.

Keywords – academic recommender system, genetic algorithm, degree recommendation, academic performance, higher education institution

INTRODUCTION

Students' success and retention are two of the most important aspects that most universities or HEIs sometimes overlook. A lot of factors can contribute to the academic performance of most students, which may include their personal background, educational background, as well as their personal interests or preferences, and personal behavior.

Previous studies confirmed that academic interest is correlated with academic performance, thus, students with a higher level of academic interest tend to possess higher academic performance. These previous studies showed that one key factor for a student to achieve academic success is by showing interest in the program or academic path that he/she has chosen. Therefore, choosing the right program becomes a crucial part in contributing to the success and retention of students in their chosen field.

The existing academic advising often relies on manual procedures and a very limited amount of data that is processed. While this research aims to obtain a higher level of accuracy and precision in terms of providing personalized recommendations as it aims to use many datasets from the students' current records and historical data. This research aims to give students personalized recommendations concerning their academic performance. The system is trained with the use of the data that is collected from different universities in the province.

The primary focus of the study is to fit the genetic algorithm in creating a robust and accurate way of giving a suitable recommendation to each student. A model will be trained using various tools with the integration of the algorithm. Various metrics will also be used to evaluate the overall performance of the algorithm in giving recommendations. Furthermore, a web-based recommendation system will be developed, integrating the trained model to be used by the students. Finally, this research aims to contribute to the advancement of recommender systems as it showcases innovative use of AI to further

foster research in adaptive recommendations technologies and will broaden the impact in research, as this can be applied to other domains and advance genetic algorithm methodologies.

LITERATURE REVIEW

According to Paytaren (2020), machine learning research on recommender systems is still in early stages. Recommender systems can generate a user's list of recommendations in two primary ways: collaborative filtering and content-based filtering. Collaborative filtering builds a model based on comparable choices made by other users and historical behavior (things that a user has previously viewed or bought, along with any ratings the user may have given those items).

Recommender systems are widely utilized in various sectors. In the context of education, various research studies have been conducted to prove its effectiveness. Previous studies have been conducted specifically for higher education students aimed at leveraging their performance as well as guiding them in their individual academic goals and success. As an example, Chang et al. (2023) studied and developed a personalized hybrid course recommendation system to assist their students with course selection decisions from different departments. They integrated three methods, such as item-based, user-based, and content-based filtering, and then they optimized the weights of the parameters to enhance the prediction accuracy. Urdaneta-Ponte (2021) also systematically analyzed the work undertaken on recommendation systems that support educational practices to acquire information related to the type of education and areas dealt with, the developmental approach used, and the elements recommended, as well as being able to detect any gaps in this area for future research work.

Doctor (2023) aimed to discover a predictive model with high acceptability, accuracy, and precision rate that should deliver a useful outcome for decision making in education systems, specifically in improving the processes of conveying knowledge and enhancing the performance of students. Rastrollo-Guerrero et al. (2020) analyzed various papers to differentiate methods and techniques that are utilized in predicting students' performance, together with the goals that they must achieve in their fields. These techniques and methods, which pertain to the area of AI, are mainly machine learning, collaborative filtering, recommender systems, and artificial neural networks. Holmes (2021) developed and evaluated the effectiveness of content filtering and collaborative filtering recommendations. The study demonstrated the potential for recommender systems to be utilized in grade prediction and early warning for students.

Kamal et al. (2023) also studied and evaluated various articles and strategies in recommender systems in Academic Choices of Higher Education, and results showed that the hybrid strategy has been the most effective method for producing recommendations. Zayed et al. (2022), research based on published research and using the same dataset, aiming to improve the results by applying hyper-tuning, which was absent in the previously

developed recommender system. Shahab (2019) presented a course recommender system that aims to improve students' career readiness by suggesting relevant skills and courses based on their unique career interests.

After synthesizing the reviewed literature and studies, it underscores the diverse applications of recommendation systems in education. However, it also discussed the different drawbacks that need to be solved to further enhance and improve its effectiveness. Ongoing research continues to address challenges and innovate new methodologies, promising further advancements in personalized learning and educational decision support systems.

PROPOSED METHODOLOGY

The researcher will employ a combination of quantitative and qualitative methods. The Academic Recommender System is a mixed-method approach, incorporating both quantitative and qualitative techniques. The quantitative aspect involves data analysis and modeling to create degree program recommendations, while the qualitative aspect encompasses the review of related literature and studies that explore existing technologies and research that will help further the research. One of the objectives of the study is to design and develop a recommendation model. To be able to achieve that, various steps will be taken.

To be able to start with the implementation and design of the Academic Recommender System, it is important to gather the data that is needed. The study revolves around the college students at five higher education institutions in Ilocos Norte, Philippines. An electronic form has been created to gather the information that is needed from the college students in the province. At least 1500 respondents for each of the institutions will serve as the dataset of the study. The information that will be gathered includes students' age, gender, current degree they are enrolled in, Year, Location, Learning Style, their grades in the different courses they have taken, the level of difficulty for each course will also be identified, total units earned, as well as their skills and interests. To ensure data privacy, a unique identifier (ID number) will be assigned to each student, and the data will also be anonymized. Each of these pieces of information plays a role in training the model as it gives information or ideas as to what degree will be suited to each student.

The data gathered will have to undergo data analysis and preparation for it to become an effective input to the model. Records with no entries in the "Degree" attribute should be omitted to establish a clear row-wise mapping for subsequent degree retrieval during the recommendation phase. Encoding categorical variables is a vital step in preparing data for machine learning tasks. When dealing with categorical data, characterized by non-numeric values such as text or categories, it becomes necessary to transform them into a numerical format for compatibility with machine learning algorithms. *Barruah (2023).* One-hot encoding will be utilized to further improve the interpretation of the raw data. There are various encoding techniques available, but it is the most widely used. It is suitable for

nominal categorical variables, where the categories have no inherent order or relationship. The idea behind one-hot encoding is to represent each category as a binary vector. After gathering and preprocessing the dataset, the next step will be the training of the model that will generate recommendations.

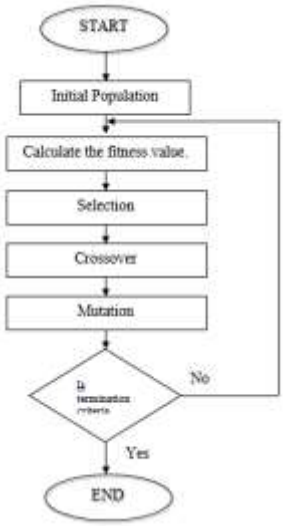

Figure 1. Genetic Algorithm

A genetic algorithm will be utilized in the model. The genetic algorithm is a natural selection-based approach to addressing optimization problems, both bounded and unbounded (Figure 1). Python, as a programming language, will be used in the design and training of the model. To apply the genetic algorithm, the following steps will be taken. The first is to represent or encode potential degree programs as chromosomes with genes representing attributes like program ID, field of study, course difficulty, and alignment with skills and interests. Next will be the fitness function creation to evaluate how well a degree program matches a student's profile. Course difficulty match, total units earned, demographic match such as the age, gender, current degree, year, learning style and skills, and interests. Weights will be assigned as well to each of the criteria mentioned based on their importance. Next is to generate the initial population, where each solution is a randomly selected degree program, which is encoded according to the chromosome structure. A tournament selection method will be utilized to choose the best solutions for reproduction. Also, crossover and mutation, which are two features of the parents' solution, will be combined. Also, introduce small changes to some offspring to maintain genetic diversity. Then, based on the identified fitness function, the fitness of the new population will be evaluated, and selection of the best solutions from the current population to be able to form the next generation. The process of crossover and mutation will be iteratively repeated until the best solution is generated. The final population will represent the best degree program tailored to the student's profile.

After the training of the model, various metrics will be utilized to evaluate the overall performance of the model in providing a robust recommendation to the students. 80 % of the gathered dataset will be used to train the model, while the remaining 20% of the data will be used as test data to validate the performance of the model. The test dataset will be used to evaluate its performance. Metrics such as Accuracy, Precision, Recall, F1 Score, and Mean Squared Error (MSE) will be used.

$$Accuracy = \frac{\#\ of\ correct\ recommendations}{Total\ \#\ of\ recommendations} \qquad Equation\ 1$$

Accuracy will measure the proportion of correct recommendations out of all the recommendations (Equation 1). A higher accuracy value signifies the model's capability to provide relevant suggestions for students.

$$Precision = \frac{True\ Positives}{True\ Positives + False\ Positives} \qquad Equation\ 2$$

Precision, on the other hand, will focus on the relevance of the recommendations provided to students (Equation 2). It measures the proportion of correct recommendations out of all recommendations made by the model. A high precision value indicates that the model makes relevant recommendations, minimizing the instances of incorrect suggestions.

$$Recall = \frac{True\ Positives}{True\ Positives + False\ Negatives} \qquad Equation\ 3$$

Recall will measure the proportion of good matches that were recommended by the system (Equation 3).

$$F1\ Score = \frac{Precision \times Recall}{Precision \pm Recall} \qquad Equation\ 4$$

F1 Score is the harmonic mean of precision and recall, which provides a balance between the two (Equation 4).

$$MSE = \frac{1}{n}\sum_{i=1}^{n} \quad n(Y_i - P_i) \qquad Equation\ 5$$

MSE will measure the average squared difference between the predicted and actual values (Equation 5).

The proposed study also aims to develop a system that integrates the trained model to be utilized by the students. The content of the system will be the students' profiles, academic grades, and records.

The user interface (UI) will be developed using the Laravel Framework, while the design will be done using Bootstrap 5 Framework, Cascading Style Sheet (CSS), and JavaScript (Figure 2). MySQL database will also be used to store students' profiles, records, and historical data that will help in training and updating the algorithm. Finally, the developed system will be deployed on Amazon Web Services as it provides scalability and reliability (Table 1).

Table 1. System Development

Component	**Technology**
User Interface	Laravel Framework, Bootstrap 5, CSS, JavaScript
Database	MySQL
Backend Processing	Python for model training and implementation
Deployment	Amazon Web Services (AWS)

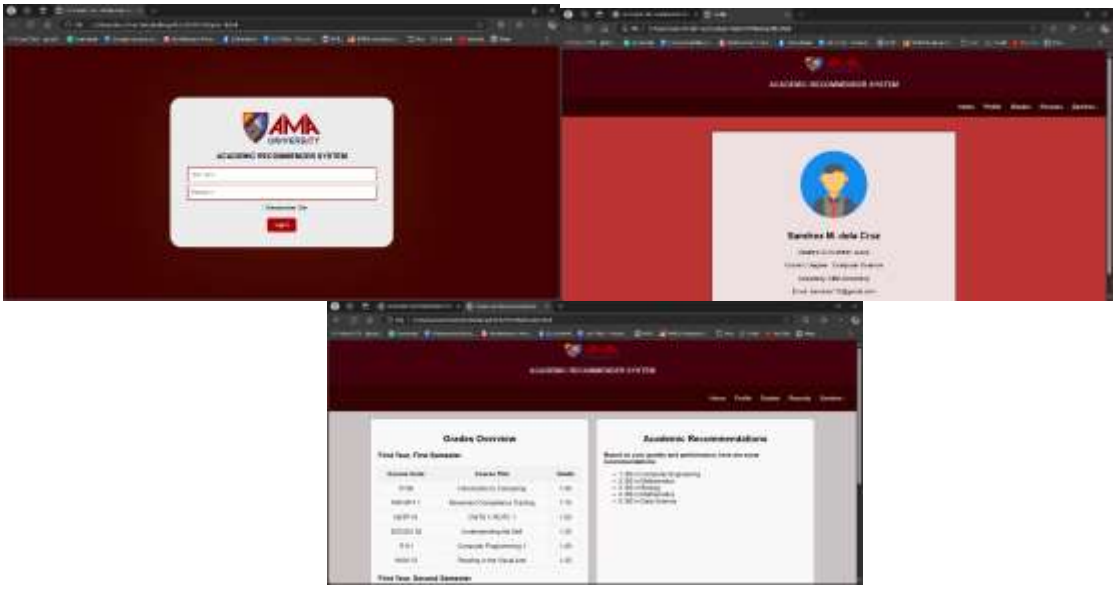

Figure 2. User Interface

In summary, the proposed system will train a recommendation model to give a robust degree recommendation to students based on various factors such as students' profiles, grades, skills, interests, and other relevant information. The genetic algorithm will be incorporated into training the recommendation model. To ensure the effectiveness of the model, various metrics will be calculated. The trained and evaluated model will then be integrated into a web-based system to help and assist students in their decision-making process, specifically in their academic pursuits.

CONCLUSIONS AND FUTURE RESEARCH

The exploration of recommendation systems within educational contexts underscores transformative potential in enhancing personalized learning and academic decision-making. The practical applications of these systems are varied and impactful, from assisting students in selecting appropriate degree programs to accurately predicting academic performance based on historical data. The proposed system aims to develop an Academic Recommender System for college students in Ilocos Norte, Philippines, utilizing a combination of quantitative and qualitative methods. By gathering comprehensive student data and employing a genetic algorithm, the system will generate personalized degree program recommendations. The research involves data collection, preprocessing, model training, and evaluation to create a web-based tool to assist students in making informed academic decisions.

Genetic algorithms have been chosen as they are particularly well-suited for complex problems where the search space is large and not well understood. It is also driven by its powerful optimization capabilities and robustness to data variability. These characteristics make the algorithm suitable for the development of an effective academic recommender system that will cater to diverse students' needs and preferences.

However, there are several areas for future research and improvement. The main objective of this study is to evaluate the performance of the algorithm in providing a robust recommendation to the students. Future research can explore integrating advanced machine learning techniques such as deep learning, which can capture complex patterns in data. Ensemble methods, which combine multiple models to improve performance, could also be investigated. Another is the addition of a more holistic view of the student's profile, which includes information beyond their academic records, such as extracurricular activities, and such can also offer insights into a student's interests and skills, leading to more tailored recommendations.

PRACTICAL IMPLICATIONS

The proposed academic recommender system will be of great advantage for the students as well as the administrators of the various higher education institutions, as it has the potential to solve some of the problems that most students are experiencing, specifically in choosing what path they must take. It can also give insights as to what the necessary and relevant skills are needed to be able to become successful in a particular field or degree program. Additionally, the utilization of genetic algorithms will be beneficial for future research as the result of the study will serve as a reference to further improve and enhance the use of the said algorithm and can be a basis for comparing its performance with other algorithms that can be utilized in giving recommendations. Overall, the development of an academic recommender system integrating a genetic algorithm will streamline the process of giving recommendations in the academic field.

ACKNOWLEDGEMENT

I would like to extend my heartfelt appreciation to the individuals and organizations who have played a significant role in supporting us throughout the development of this concept paper. First, we wish to acknowledge the valuable contributions of the members of our research team: Dr. Gerard Nathaniel C. Ngo, Dr. Jenny Lyn V. Abamo, Dr. Mark Jayson Lay, and Dr. Jane Kristine Suarez. Their active participation in giving valuable insights, discussions, and reviews has significantly shaped the ideas presented in this concept paper.

Furthermore, we are grateful to the various HEIs in Ilocos Norte for providing us with the necessary resources needed to conduct this research. Their support has been indispensable in gathering relevant information for the realization of our concept. Finally, I want to express our deep appreciation to my beloved parents, siblings, and fiancée, Justine. Their understanding and support throughout this research endeavor have been a constant source of motivation, propelling us to strive for academic excellence.

DECLARATIONS

Conflict of Interest

I affirm that there are no conflicts of interest that could potentially influence the outcomes and objectives of the recommender system in educational institutions. I have no financial or personal relationships with any individuals, organizations, or entities that might compromise the impartiality of the research.

Informed Consent

Consent will be obtained from all participants involved in the study. It is crucial to ensure that they are fully informed about the purpose, procedures, potential risks, and benefits of their involvement. They will be provided with a clear explanation of their rights and their voluntary nature. Confidentiality and anonymity will be maintained throughout the study, and consent forms will be obtained before their participation.

Ethics Approval

I recognize the significance of ethical research practices and commit to conducting the study with utmost integrity, adhering to all relevant guidelines and regulations. I take complete responsibility for the precision and authenticity of the information presented in this proposal.

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Author's Biography

Sandrex Mamuad dela Cruz is a Master of Science in Computer Science candidate at the School of Graduate Studies, AMA Computer University. He holds a Bachelor of Science in Computer Engineering (2019) from Mariano Marcos State University, Philippines. His research involves algorithm integration and implementation for an accurate recommendation for college students. He currently works as an instructor in a state university in the province of Ilocos Norte.