

Digital Smart Navigator Design and Implementation of an Academic Map Navigation System

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Abstract: In the modern world, students are unable to find their way in the career development process and the academic planning of their studies is also not clear. The proposed paper will create a solution to the practical problems of the current college students by creating an Academic Graph Navigation System that will be implemented with a Digital Intelligence Learning Navigation system. It has front-end and back-end separation architecture. HTML5, CSS3, and JavaScript are used in the front end to develop a dynamic interface that responds to user inputs and the Flask framework is used in the back end to offer standard API services, as well as the Neo4j graph database to store knowledge graphs of academics. The system combines different data sources like professional training courses, curriculum systems, vocational skills, job demands, etc., and forms a four-layered model of academic knowledge graph, namely major-course-skill-position. This system offers its users intelligent question-answering features which include professional advice consultation, career direction exploration and course information retrieval, through the use of a natural language processing and rule matching engine based on native JavaScript. Moreover, this program can be offered to students in college who would have comprehensive guidance on academic planning and career growth in the university till they graduate and get employed, so it is quite effective in solving such issues as asymmetry of information and lack of personalization of the traditional approach to academic guidance. It is a good potential for advertising and implementation.

Keywords: Knowledge Graph; Academic Planning; Neo4j; Flask; Intelligent Recommendation.

1. Introduction

As the massification of the higher education progresses, students are also being exposed to a more complicated situation of making choices in their studies and career growth. It is evident that it should be ensured that the Ministry of Education will apply the most advanced technologies, including artificial intelligence and big data, to conduct monitoring work on the quality of compulsory education [1]. The same time, the implementation of such digitalization practices as the MOOC Westward Plan is one of the examples of the deep promotion of educational digitalization, which proves the possibility of the use of data as an instrument of the improvement of the quality of education [2]. This policy trend shows that there is a tendency to introduce artificial intelligence and big data technology into the system of modern higher education reforms, with the aim of enhancing accuracy and personalization of the services offered by the institution.

In the field of academic planning and career guidance, the enabling role of artificial intelligence technology is becoming more and more obvious. Fan Yunan [5] concluded from empirical studies that artificial intelligence has great advantages in career matching and personalized learning support, and intelligent recommendation system can effectively improve the accuracy of job matching and submission efficiency. Zhao Mingtian et al. [7] pointed out that college student career guidance under the background of artificial intelligence should be personalized career guidance, strengthen career planning guidance, and cultivate students practical employment ability.

Regarding academic quality monitoring, Xiao Ming et al. [8] developed an academic early warning model of college students using artificial intelligence technology. Through the

analysis of online behavior and other information about students they managed to predict accurately the academic risks of students. According to Sun Yu et al. [9], the artificial intelligence technology can be used successfully to address such issues as long feedback loops, high subjectivity of evaluation, and absence of scientific decision-making in traditional academic quality monitoring. Moreover, big data analysis technology has also proven to be quite valuable in precision-based career guidance. Liu Wei [10] suggested that learning, living and activity information of students during their school years can be used to create a portrait of students career aspirations with the help of data mining technology and therefore precise career planning advice will be provided.

This paper constructs and implements a system of "Digital Intelligence Learning Navigation" - Academic Graph Navigation System. The system takes knowledge graph technology as its core, builds an academic knowledge graph that includes four layers of entities: "major-course-skill-position", integrates functional modules like intelligent question answering, personalized recommendation, academic status analysis, and career matching evaluation, and forms a closed-loop navigation service from academic cognition to career development. This system is important for improving the intelligence level of academic guidance for college students and helping them make accurate academic and career plans.

2. System Design

2.1. Overall System Architecture

This system is based on three-tier architecture design as shown in Fig.1.

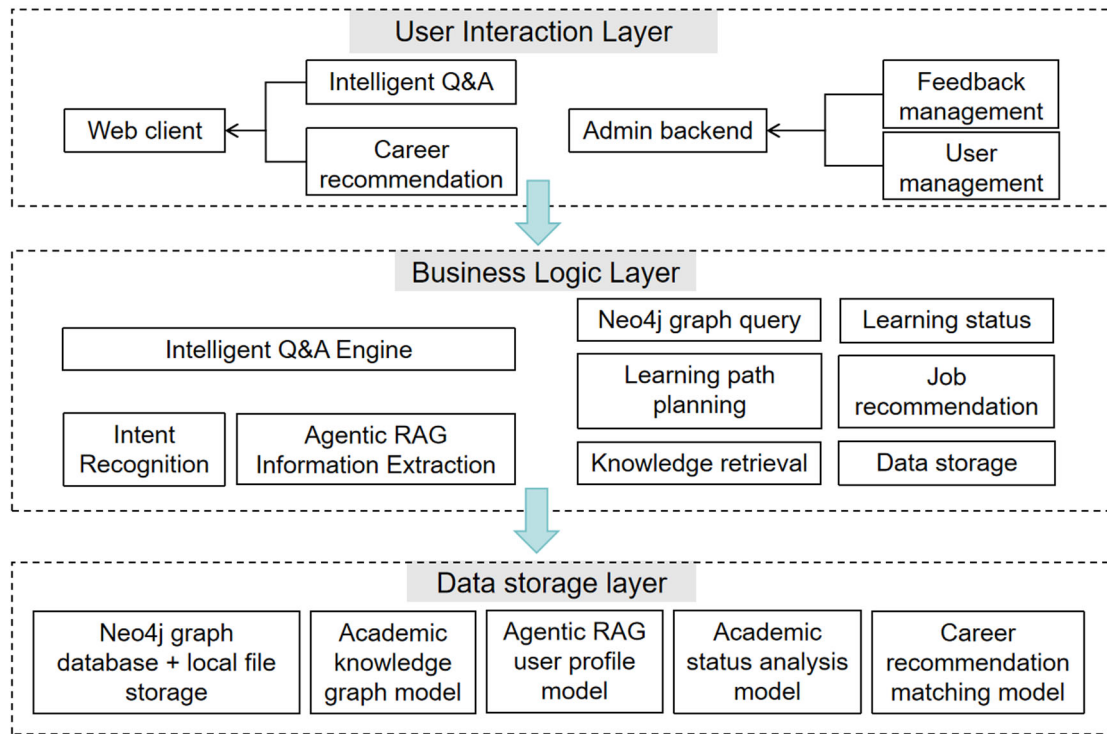


Figure 1. System Overall Architecture Diagram

The user layer has two entries to the Web, academic navigation and career planning services to student users and back-end management functions to administrators. The business layer contains the core business logic including intelligent question-answering engine, career recommendation engine, analysis of academic status, learning path planning, and feedback learning which is the essence of

implementation of system functions. In the data layer, the academic knowledge graph is stored in a Neo4j graph database and local storage is combined to handle the user personas and learning record information, with an interface that provides access to the upper layer data.

2.2. System Functional Module Design

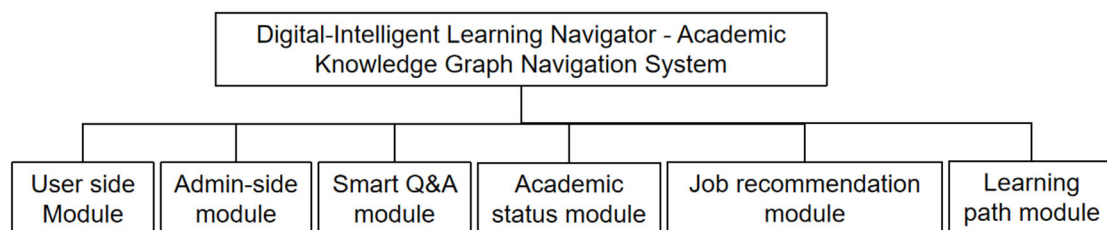


Figure 2. System Functional Module Structure Diagram

Fig.2 presents the system functional module of the structure, which is divided into two modules: the user end and the management end. The five sub-modules in the user end are as follows; intelligent Q&A, academic status, career suggestion, learning plan and feedback suggestions, which are all the aspects that the student requires to be planned during the course of their studies and work. The management side has five submodules such as overview dashboard, knowledge graph control, users control, data import and feedback control, maintenance of the systems and the database updating.

2.3. Database Design

(1) Knowledge Graph Data Model Design

The knowledge graph data model has a four-layer progressive structure of major-course-skill-position, and there is a one-to-many inclusion relationship between the adjacent layers. The major layer contains training programs and grade-specific academic advice, course layer contains course names, categories and credits, skill layer contains ability elements and proficiency levels, and position layer contains career directions and technical ability requirements. This model allows mapping on a layer-by-layer basis and reasoning about knowledge based on academic guidance objectives to job skill requirements.

(2) Relational Database Design

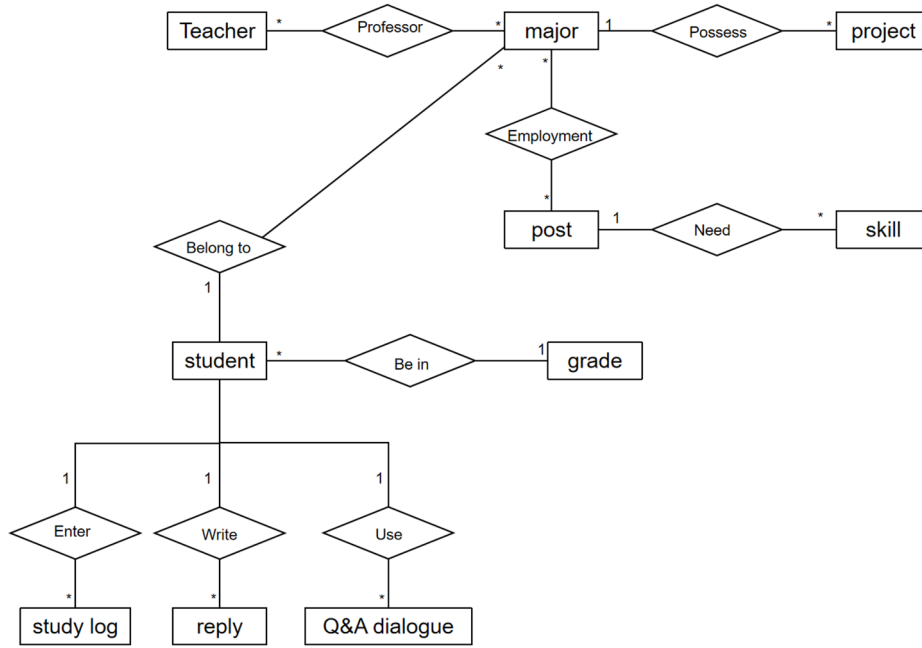


Figure 3. Data Model E-R Diagram

The structure of the relational database is presented in Fig.3 and it comprises four fundamental data tables, namely, user, learning record, feedback, and question-answer pair. The account role and status are stored in the user table. Learning record table is a table that relates learners to courses by keeping the level of mastery, time spent on learning, and percentage of homework done. In the feedback table, users will rate the system and make suggestions about how to improve the system. Tables are related through usernames and have one-to-many association relationship.

3. Key Technology Implementation

3.1. Knowledge Graph Construction

(1) Multi-source Data Extraction and Fusion

The data will be extracted in the system by drawing entities out of different sources including professional training programs, curriculum systems and job demands. The knowledge extraction is completed using the CSV batch import method to complete it. The information obtained has been cleaned and unified into a single format that forms standardized triples which serve as the data basis of the construction of knowledge graphs.

(2) Knowledge Graph Storage and Query

The system uses Neo4j graph database as the knowledge graph storage, with nodes being used to represent entities like majors, courses, skills and positions and edges representing association relationships between entities. It can be used to query multi-hop relationships by using native graph traversal features of Neo4j, create indexes to optimize queries, and offer knowledge retrieval answers to intelligent question answering and recommendation services.

3.2. Intelligent Q&A Engine

The intelligent question-answering service uses a rule matching and knowledge retrieval method. It builds a multi-layered intent recognition system, which divides user questions into different categories like professional advice, direction consultation, course inquiry, and job matching.

Regular expressions and keyword dictionaries are used to achieve intent classification and slot filling. In the case of simple factual questions, answers are directly produced by retrieving the information in the knowledge graph. Besides, with the introduction of the Agentic RAG mechanism, it is possible to extract important academic data, including grades, GPA, and rankings, based on the conversations with users, which will result in an upgrade of passive response to active information gathering, simplifying the process of answering questions and effectively improving the experience of the user.

3.3. Personalized Recommendation Algorithms

The algorithm of career recommendation is used to determine the level of matching of user personas and job knowledge graphs. The score of the matching degree takes into account four aspects, which are professional match, skill matching, interest matching, GPA factor. Last but not least, the Top-N best jobs will be suggested in a decreasing manner according to the overall score. The proposed learning path suggestion system has been designed with respect to the skills that need to be developed by the target job, and it can combine the existing skills of the user to develop a progressive learning path as follows: basic stage - advanced stage - professional stage. It allows to make plans on the fundamental courses and real-life projects that should be undertaken at every step, taking into consideration the prerequisites between the courses and the structure of the hierarchy of the skills, allowing the user to meet the requirements of his or her career goals through the best possible way and getting an exact link between the present capabilities and the desired occupation.

3.4. Intelligent Academic Status Analysis

The academic status intelligent analysis service will produce the report of the evaluation of the academic status, depending on the grades of courses that are separately put in by users. The service would then use the information provided to determine the level of mastery and homework accomplishment of every subject to compute the weighted score and the average of the subjects. The charts of the visual display of the system can be generated as per the results of the

analysis to provide a clear picture of the grade distribution and structure of ability of each subject so that the user can easily understand his or her academic performance. The improvement suggestions were created based on the data (e.g., weak subjects, grades distribution) according to the diagnosis, which is a full loop from the collection of the data to the diagnosis of the data, and the intelligent guidance of the data.

4. System Implementation and Operational Effects

4.1. Development Environment and Technology Selection

The front end of the system is designed on native HTML5,

CSS3 and JavaScript which makes it unnecessary to rely on other frameworks that would add an extra layer of complexity in deployment. The Python Flask framework has been used to create a back end with RESTful API services and Flask-CORS was applied to address cross domain problems. The knowledge graph will be kept in Neo4j graph database, and there is also a local JSON data storage facility to ensure that the system will work as usual even when the database is not available. LocalStorage is employed to store personas of users, learning history and feedback information. Chart.js can be used to visualize charts, allowing the user to display academic data easily.

4.2. User-Side Implementation Effects

(1) Intelligent Qquestion-answering Interface



Figure 4. Question-answering Interface

The intelligent question-answering interface has an instant messaging-style interactive layout as illustrated in Fig.4, where the left and right sides are separated into a chat message area and an information panel respectively. The input box at the bottom of the system allows users to enter questions and the system responds rapidly. On the top of the interface there are quick question buttons that can be used to ask general advice, preparation for postgraduate entrance examination,

professional projects and other problems. The one-click sending of high-frequency questions is facilitated by the quick question area at the bottom. System functions descriptions are shown on the right panel, which facilitates interaction with the question-answer and viewing of information.

(2) Academic Status Visualization

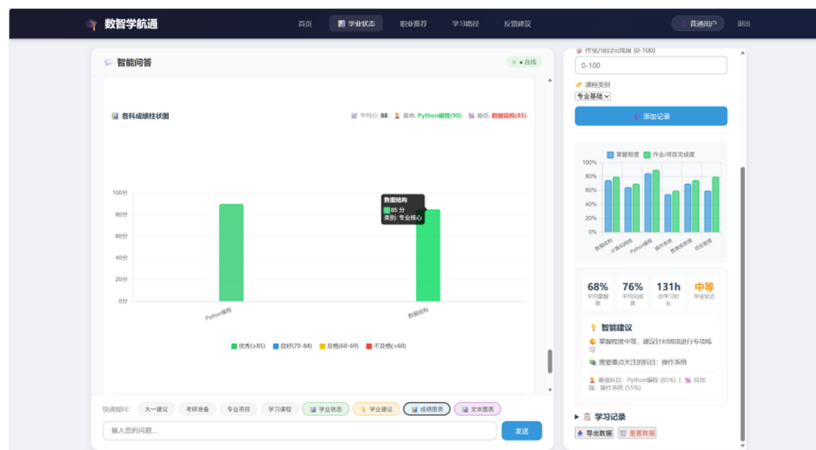


Figure 5. Academic Status Bar Chart

The academic status is presented in Fig.5, where the bar chart is at the center and it presents the level of mastery of each course as well as the degree of completion of homework with different levels representing excellent, good, pass, and fail. Statistical data including average score, highest score and lowest score are presented above the chart to aid in coming

up with intelligent diagnostic conclusions and improvement recommendations and enable users to identify weaknesses in their academics intuitively.

(3) Career Recommendation and Learning Path

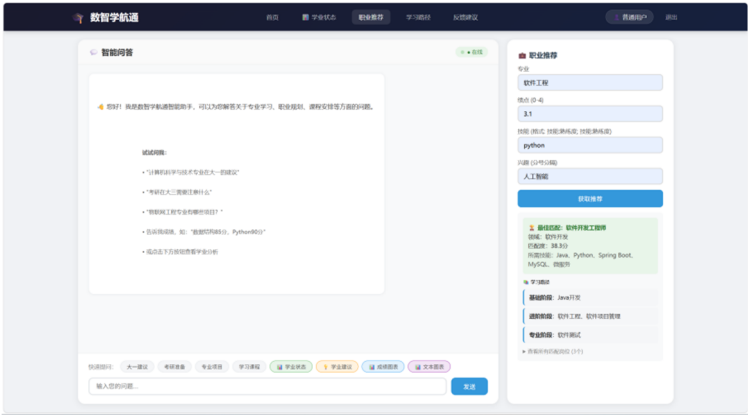


Figure 6. Career Recommendation



Figure 7. Learning Path

The example of the career suggestion is provided in Fig. 6. The user will then be asked to provide their major, GPA, skills and interests and the system will determine the degree of matching between the job positions and the scores and display the best match job position and skill requirements of each job in descending order. The service of learning path can be seen in Fig.7. It also produces a course list of the three stages of basic stage - advanced stage - professional stage as per the

skill needs of the target job. All courses in the different levels are organized on the basis of the correlation that gives the user an idea of what should be done to improve his or her ability.

4.3. Management Backend Implementation Effects

(1) Knowledge Graph Implementation

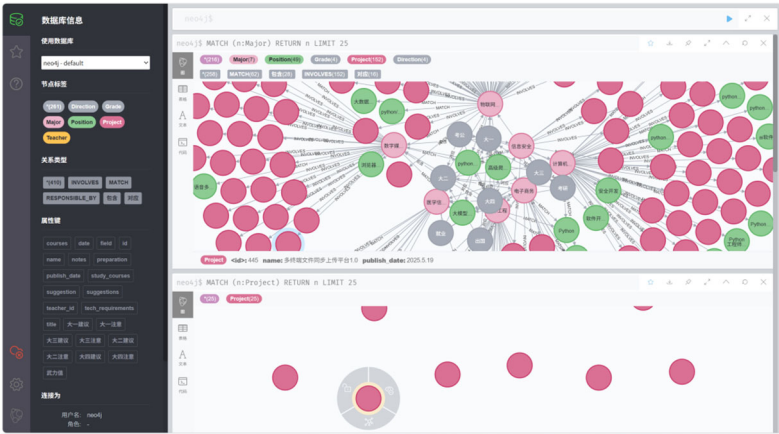


Figure 8. Knowledge Graph

As it is presented in Fig.8, the four-layer entities and their relationships are displayed visually by the knowledge graph management interface: major - course - skill - position. The synonym management feature allows administrators to add term mapping relationships to improve the sentence understanding of the question-answering service. It has a batch import of CSV format data with classification, which

includes five types of data sources: teacher projects, job requirements, student information, major suggestions, and direction preparation, allowing dynamic updating and expansion of the knowledge base.

(2) User and Data Management



ID	用户名	姓名	邮箱	角色	状态	注册时间	操作
1	user	普通用户	-	用户	正常	2020/1/1	启用 禁用 删除
2	zhangan	张三	zhangan@example.com	用户	正常	2020/1/15	启用 禁用 删除
3	lisi	李四	lisi@example.com	用户	正常	2020/2/1	启用 禁用 删除
4	111	111	-	用户	正常	2020/3/16	启用 禁用 删除
1	admin	系统管理员	admin@example.com	管理员	正常	2020/1/1	启用 禁用 删除
2	manager	运营管理员	manager@example.com	管理员	正常	2020/1/16	启用 禁用 删除

Figure 9. User Management



操作	数据源	数据量
导入数据	教师项目	1000
导出数据	教师项目	1000
导入数据	学生信息	1000
导出数据	学生信息	1000
导入数据	专业建议	1000
导出数据	专业建议	1000

Figure 10. Data Management

The user management interface, shown in Fig. 9, presents information about all the registered users and allows for filtering by role and querying by status. Administrators can enable/disable, edit and delete users. The data management interface, shown in Fig. 10, aggregates statistics such as the total number of queries, number of successful queries, number of ratings and number of questions-answers pairs. The feedback list presents ratings and suggestions for improvements submitted by the users in a centralized manner, offering data support for ongoing system improvement.

5. Conclusion

This article deals with the practical problems of college students who are not provided with personal guidance in academic planning and have unclear career development. It creates and develops a Digital Intelligence Learning Navigation - Academic Graph Navigation System. The system has a front-end and back-end separation architecture. The front end is developed on native Web technology, whereas the back end offers API services based on the Flask

framework. It cooperatively handles multi-source data with Neo4j graph database and local storage.

The main research achievements are as follows:

(1) Developing an academic knowledge graph model of four-layer entities: major-course-skill-position, which allows the systematic structuring and association of different academic data.

(2) Developing an intelligent question answering service based on rule matching and synonym expansion to support various kinds of interactive services, e.g., professional consultation, career exploration, course information search, etc.

(3) Implementing an intelligent academic status analysis module, which generates visual charts and personalized improvement suggestions through user-entered learning data.

The system has been implemented and the test of functionality has been conducted to prove that it can be done. It will further be improved in the future by incorporating large language models to provide the system with the question-

answering interaction features, as well as the development of mobile applications to make the system more versatile and use it in more situations, which will increase the intelligence level and promotional usage value of the system.

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