Finetuned Model ViT5 Combined with NSGA-II for Optimal Timetable Selection

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Abstract: This study addresses a pressing issue faced by Vietnamese university students, particularly at the Vietnam-Korea University of Information and Communication Technology (VKU): the complexity of constructing optimal class schedules. The manual process is time-consuming—often taking 30 minutes to an hour—and mentally exhausting, requiring students to navigate extensive course catalogs, avoid time conflicts, meet credit requirements, and consider personal preferences. Existing digital tools often fall short in interpreting natural language inputs or adapting to individual constraints, resulting in inefficiencies and user dissatisfaction.

To overcome these limitations, we propose an AI-powered scheduling assistant that integrates a fine-tuned ViT5 language model with the NSGA-II multi-objective optimization algorithm. The ViT5 model interprets students' free-form language inputs and converts them into structured constraints, while NSGA-II generates a set of Pareto-optimal timetable solutions based on factors such as conflict avoidance, workload balance, and user-defined preferences. The entire pipeline is orchestrated through n8n, a low-code automation platform that ensures seamless interaction between components.

Our system provides each user with multiple customized schedule options, significantly reducing planning time while improving usability and satisfaction. This interdisciplinary solution—combining NLP, evolutionary computation, and automation—not only enhances the scheduling experience but also contributes to the broader objectives of smart education and institutional digital transformation.

1 Introduction

Timetable scheduling poses a significant challenge for university students, particularly at institutions with diverse academic offerings like the Vietnam-Korea University of Information and Communication Technology (VKU). Each semester, students must manually create schedules by navigating extensive course catalogs, ensuring no time conflicts, and meeting credit requirements while considering preferences like preferred instructors or class times. This process is time-intensive, often taking 30 minutes to an hour, and can be mentally exhausting due to the need to balance multiple constraints. Existing digital scheduling tools, while somewhat effective, often fail to process natural language inputs or adapt to nuanced individual preferences, resulting in inefficient schedules.

The integration of artificial intelligence (AI) and natural language processing (NLP) offers a promising solution to these issues. Large language models (LLMs) like ViT5 excel at structuring natural language inputs, making them ideal for converting unstructured student requests into structured constraints. Concurrently, multi-objective optimization algorithms like NSGA-II (Non-dominated Sorting Genetic Algorithm II) are effective in optimizing conflicting scheduling criteria, such as minimizing class overlaps, ensuring balanced weekly distributions, and aligning with student preferences. Despite these advancements, the application of such technologies in timetable scheduling, particularly in Vietnamese higher education, remains limited, highlighting a research gap.

This study introduces an AI-driven scheduling assistant that combines a fine-tuned ViT5 model with the NSGA-II algorithm to generate optimal, personalized timetables for university students. The ViT5 model, fine-tuned on a Vietnamese dataset, interprets students' natural language inputs—such as requests for specific class times, days, or teachers—and transforms them into structured JSON constraints. These constraints are then processed by NSGA-II, which produces Pareto-optimal timetables by minimizing time conflicts and ensuring even class distribution throughout the week. This approach streamlines the scheduling process, enhances tim etable personalization and quality, and supports the digital transformation of higher education while contributing to the broader vision of smart education.

2 Related Work

Alghamdi et al. [2] provide a comprehensive review of classical and modern optimization techniques used in university timetable scheduling, including constraint-based methods, heuristics, and metaheuristics. These approaches, however, primarily operate on well-defined **hard constraints**, assuming that all user requirements are already structured and machine-readable. In real-world scenarios, students often express their preferences using natural, unstructured language, such as "I don't want classes on Monday afternoon" or "I prefer continuous morning sessions." Translating such informal expressions into formal constraints is a complex task that traditional systems are not equipped to handle. To overcome this limitation, we propose leveraging **ViT5**—a large language model pre-trained specifically for Vietnamese—to convert free-form user input into structured JSON constraints. This translation enables seamless integration with optimization algorithms and allows for personalized, intent-driven scheduling. In contrast, Wan et al. [1] explore a more ambitious integration of LLMs by allowing the model to directly replace the three core components of the NSGA-II genetic algorithm: selection, crossover, and mutation.[1] While their approach achieves promising results in the domain of surgical scheduling, it relies heavily on the LLM's semantic reasoning capabilities. This raises concerns around transparency, controllability, and reproducibility—especially in domains that demand reliability and adaptability. Furthermore, existing general-purpose LLMs are typically not optimized for Vietnamese, limiting their effectiveness in our specific context. To strike a balance between automation and control, we adopt a hybrid architecture: **ViT5 is utilized solely for semantic parsing**, transforming natural language user inputs into structured constraints. These constraints are then processed by a conventional NSGA-II algorithm, which generates multiple Pareto-optimal timetables based on student preferences, workload distribution, and scheduling feasibility. This separation of responsibilities retains the interpretability and stability of traditional algorithms while benefiting from the language understanding capabilities of LLMs. Further supporting the viability of NSGA-II, Hafsa et al. [5] successfully applied it to a professional timetabling problem at Mandarine Academy. However, like previous studies, their approach presupposed the availability of structured constraints and did not address the challenge of interpreting user intent from natural language—underscoring the novelty of our contribution. In summary, our work introduces a controlled, language-adaptive approach that bridges the gap between human language and algorithmic optimization. By combining ViT5 for semantic understanding and NSGA-II for robust multi-objective scheduling, we offer a scalable, user-friendly solution tailored to Vietnamese-language educational environments.

3 Datasets

Building on the hybrid architecture described above, this section outlines the process of constructing a training dataset for the ViT5 model, which is responsible for interpreting natural language scheduling preferences. Unlike structured inputs, user requests in Vietnamese are often informal and diverse in expression. To ensure ViT5 can accurately translate such inputs into machine-readable constraints, we developed a multi-stage data generation pipeline tailored to reflect realistic, student-centered language patterns.

3.1 Dataset Generation for ViT5 Model

To equip ViT5 with the ability to understand and accurately translate natural language queries into structured scheduling constraints, we designed a comprehensive four-stage data generation pipeline, illustrated in **Fig. 1**. This pipeline was carefully constructed to capture the variability and nuance of real-world student expressions while maintaining consistency in the corresponding structured outputs. By simulating realistic user preferences and progressively increasing the complexity of input queries, the dataset enables ViT5 to generalize effectively across a wide range of intent formulations. **Fig. 1**.

[1] https://www.scitepress.org/Papers/2024/128944/128944.pdf

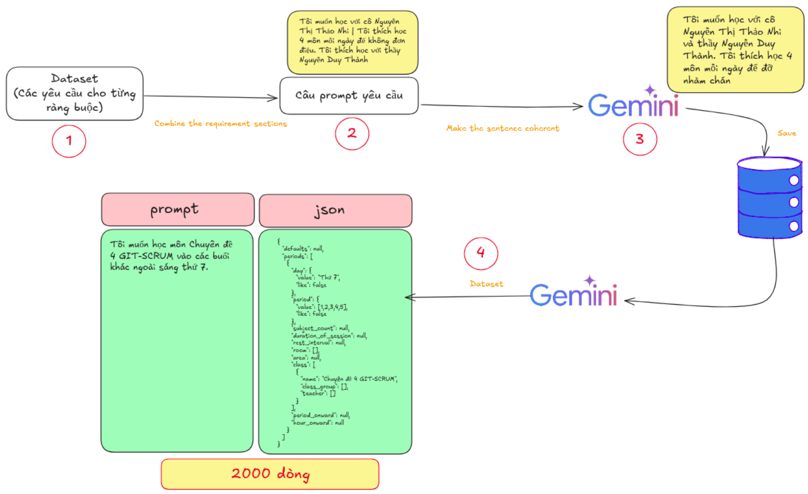

Fig. 1: Data processing pipeline for ViT5 training

Stage 1: Single-Intent Query Construction. We began by manually curating a dataset of fundamental user preferences, each representing a single scheduling intent—such as avoiding specific days, preferring morning slots, or limiting gaps between classes. These reflect commonly encountered student needs in Vietnamese educational settings. Examples are shown in **Fig. 2**.

Prompt	Type
Tôi muốn được cô Lê Xuân Việt Hương dạy	teacher
Tôi thích học với thầy Phạm Nguyễn Minh Nhựt	teacher
Tôi muốn học cô Nguyễn Thị Thanh Ngà	teacher
Tôi thích được thầy Huỳnh Công Pháp dạy	teacher
Tôi muốn học với cô Lê Thị Kim Tuyến	teacher
Tôi thích học khu K	area
Tôi muốn học ở khu V	area
Tôi thích học ở khu vực K hơn	area
Tôi muốn đến khu V để học	area
Tôi thích khu K vì gần nhà	area

Fig. 2: Examples of single-intent user queries in Vietnamese

Stage 2: Multi-Intent Query Composition. Since real-world queries often contain multiple preferences, we systematically concatenated the single-intent sentences into more complex multi-intent queries. This step enhances model robustness by introducing greater linguistic variation and realistic phrasing. Sample multi-intent queries are presented in **Table 2**.

Table 1: Examples of synthesized multi-intent user queries

User Query Example
Em không muốn học vào sáng thứ Hai và muốn các buổi học diễn ra liên tục trong buổi sáng.
Em thích học từ thứ Ba đến thứ Sáu và tránh lịch học bị ngắt quãng giữa các tiết.

The next two stages—parsing into structured JSON and augmenting data with paraphrased variations—are described in subsequent sections (or could be added next depending on your thesis layout).

Table 2: User query

Câu yêu cầu	User query
Tôi muốn học với cô Nguyễn Thị Thảo Nhi | Tôi thích học 4 môn mỗi ngày để không đơn điệu. Tôi thích học với thầy Nguyễn Duy Thành	I want to study with Ms. Nguyen Thi Thao Nhi | I like studying 4 subjects each day so it's not monotonous. I like studying with Mr. Nguyen Duy Thanh.

Stage 3: Following the concatenation, the generated sentences often lacked natural linguistic fluency. To address this, we employed the Gemini model to refine the phrasing and enhance the naturalness of the language, mimicking human-like expression, as shown in **Tab. 3**

Table 3: User query

Câu yêu cầu	User query
Tôi muốn học với cô Nguyễn Thị Thảo Nhi và thầy Nguyễn Duy Thành. Tôi thích học 4 môn mỗi ngày để đỡ nhàm chán	I want to study with Ms. Nguyen Thi Thao Nhi and Mr. Nguyen Duy Thanh. I like studying 4 subjects each day to avoid boredom.

Stage 4: Upon successful refinement, the data was stored. We then further processed this data using the Gemini model to generate the corresponding output in JSON format. This JSON structure was custom-designed based on the inherent

constraints of the problem and to facilitate seamless processing by the NSGA-II algorithm.

Upon completion of the aforementioned steps, we gathered a dataset of 2000 entries, structurally represented in the overview **Fig. 1**. This dataset comprises two columns: the first containing the user request, and the second containing the corresponding JSON structure.

3.2 Data collection for the NSGA-II algorithm

We proceeded to scrape data from the university's website at [6]. Following several data normalization and processing steps, the resulting dataset is presented in **Fig. 3**.

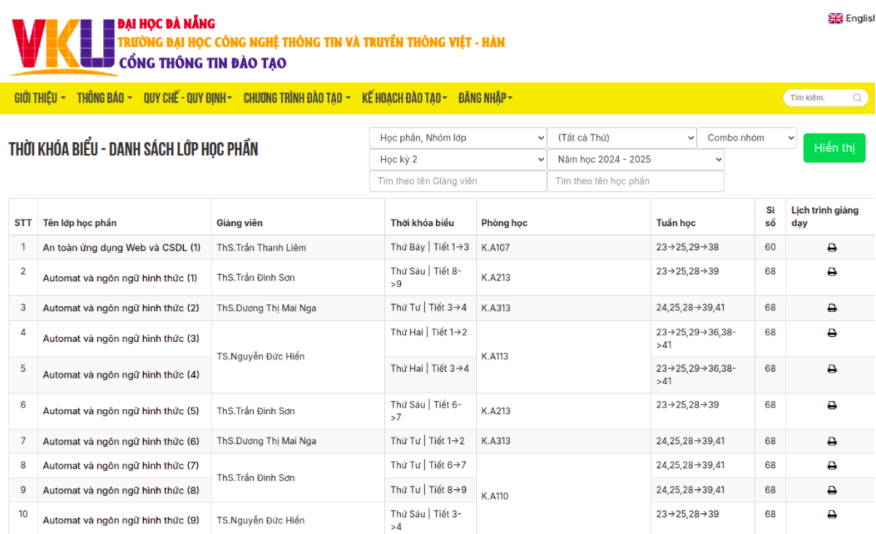

Fig. 3: Data collection for the NSGA-II algorithm

This dataset, in conjunction with the generated JSON structures, will be utilized as input for the NSGA-II algorithm to perform timetable optimization.

4 Two stages to process optimal timetable selection

4.1 Stage 1 - Text-to-JSON

As you can see in **Fig. 4**, at this stage, we trained based on the VIT5 model and the data prepared in Section ... with the aim of converting from natural language to JSON (this is a crucial parameter to feed into the NSGA-II algorithm). Since the VIT5 model has been pre-trained on a Vietnamese dataset, its semantic understanding is very good. Leveraging this strength, we fine-tuned the model's output to meet our need for text-to-JSON.

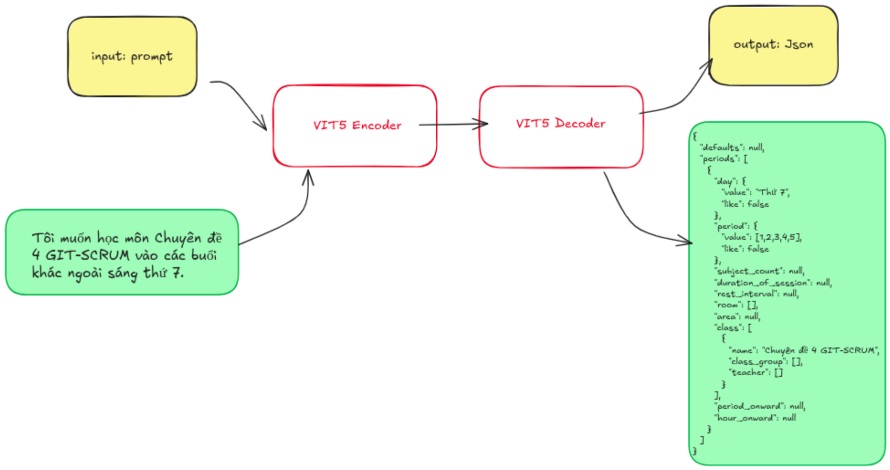

Fig. 4: Fine-tuning the VIT5 model for the text-to-JSON task

4.2 Stage 2 - Timetable optimization

At this stage, we pass the parameters from Stage 1 (JSON) and the list of subjects that a student takes in that semester. These two parameters are fed into the NSGA-II algorithm to perform the optimization of the schedule. The project utilizes a set of priority weights to determine the importance of each criterion.

Table 4: Weights and Priority Levels of Timetabling Criteria

Criterion	**Weight**	**Priority Level**
teacher	4.0	High priority
class_group	4.0	High priority
day	3.0	Balanced distribution
period_onward	3.0	Consecutive learning
hour_onward	3.0	Consecutive learning hours
periods	2.0	
subject_per_session	2.0	
subject_per_day	2.0	
subject_count	2.0	
room	1.0	
rest_interval	1.0	

The system uses priority weights to optimize teacher and class group allocation and ensure efficient scheduling in terms of time and space. The NSGA-II algorithm iteratively improves schedules using input data (periods, days, rooms, teachers) through selection, crossover (AND/OR), and mutation. The goal is to find the best schedule for effective and scientific management and allocation.

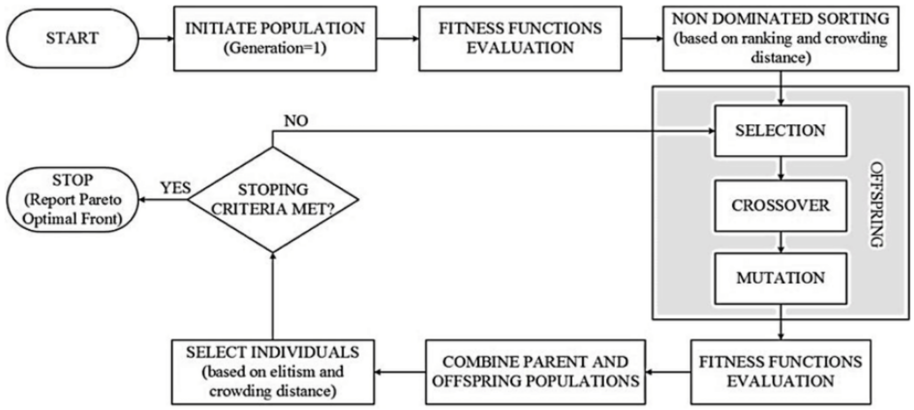

Fig. 5: Workflow of the NSGA-II algorithm

5 Experimental Results

5.1 VIT5

Currently, the evaluation results are quite promising, with notably good ROUGE scores and near-perfect accuracy in generating the JSON string, indicating that our model has effectively understood the data structure. However, the accuracy of the content within the generated JSON fields is still limited, at only 42.9%. This is primarily attributed to insufficient training data and some inaccuracies within the existing data. In the near future, we plan to focus on improving the data quality to enhance the overall accuracy of the model.

Table 5: Fine-tuned VIT5 model accuracy for text-to-JSON

JSON Accuracy	Field Accuracy	ROUGE-1	ROUGE-2	ROUGE-L
98.9	42.9	90.1	88.8	88.2

5.2 NSGA-II

As we mentioned previously, the input for the NSGA-II algorithm consists of the list of courses for the semester and the user's desired preferences for timetable scheduling. Based on these preferences, we provide a list of the most optimal timetable options for the user's reference.

Fig. 6, illustrates the results obtained when we input two parameters:

With the first parameter, as shown in Table **Tab. 6**, being the list of courses, the user will select the courses that the student will take in that semester.

The second parameter, as shown in **Tab. 7** represents the user's desired personal preferences.

Fig. 6: Results after processing with the NSGA-II algorithm

Table 6: List of subjects

Danh sách các môn	**List of subjects**
Phân tích và thiết kế giải thuật	Algorithm Analysis and Design
Triết học Mác - Lênin	Marxist-Leninist Philosophy
Học máy	Machine Learning
Chương trình dịch	Compiler
Chuyên đề 2 (IT) _Ite_Low code, No code_Automation	Special Topic 2 (IT) _Ite_Low code, No code_Automation
Tiếng Anh nâng cao 4	Advanced English 4
Pháp luật đại cương	Fundamentals of Law

6 Conclusion

In this paper, we have presented a novel integration of the VIT5 model and the NSGA-II optimization algorithm to address the complex problem of university student course timetabling. By leveraging the Vietnamese semantic understanding capabilities of the VIT5 model and the multi-objective optimization prowess of NSGA-II, we have demonstrated promising initial results in generating feasible timetables. However, the current accuracy remains suboptimal due to limitations in both the quality and quantity of the available dataset. Future work will focus on the rigorous enhancement of data quality and expansion of the dataset to improve the overall performance and robustness of the proposed approach.

Table 7: User Requirements

Yêu cầu người dùng	**User Requirements**
Tôi muốn học các môn vào buổi sáng, và tôi thích học thầy Mai Lam nhé.	Prefer to take courses in the morning, and I would like to have Mr. Mai Lam as the instructor.

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