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Teaching Non-Robotics Major Students Robot Design Technology with Aids of Large Language Model-Inferred Approach

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Abstract: The rapid advancement of robotic technology has broadened its applications across diverse fields, making it increasingly important for students, even those not specializing in robotics, to acquire a fundamental understanding of robot design technology. However, traditional teaching methods, which often rely on conventional lecture formats, may not effectively cater to the diverse educational backgrounds of non-robotics majors. This paper proposes the application of the large language model-inferred approach as an innovative pedagogical strategy to enhance the learning outcomes of these students. Four primary pillars build the proposed teaching model: Reasoning assistance for basic knowledge, visualized comprehension for robotic mechanism, support via similar case studies and performance feedback. Through detailed discussion and analysis, this study demonstrates that integrating these elements into a cohesive, iterative teaching process improves theoretical comprehension and fosters critical thinking, practical problem-solving, and creative innovation.

1. Introduction

In recent years, the pervasive influence of robotics has extended into various industries, educational sectors, and daily life. Consequently, it has become essential for students from non-robotics disciplines—such as business, arts, or general engineering—to grasp the fundamental principles of robot design technology. However, traditional lecture-based methods often fall short in addressing the diverse educational backgrounds of non-specialist students. To address these challenges, this paper proposes a large language model-inferred approach as an innovative pedagogical strategy to enhance the learning outcomes of non-robotics majors. The proposed teaching model is built upon three primary pillars: reasoning assistance for basic knowledge, visualized comprehension for robotic mechanisms, and case learning support. Through detailed discussion and analysis, this study demonstrates that integrating these elements into a cohesive, iterative teaching process not only improves theoretical comprehension but also fosters critical thinking, practical problem-solving, and creative innovation.

Traditional robotics education has predominantly been structured around lecture-based instruction, laboratory experiments, and design projects that assume a baseline proficiency in mathematics, programming, and engineering principles [1]. These courses often employ a “one-size-fits-all” curriculum that may not cater to students from non-robotics or non-engineering backgrounds. As a result, students with limited technical expertise frequently encounter challenges in grasping the theoretical underpinnings of robot design, integrating multidisciplinary knowledge, and applying abstract concepts in practical settings.

Recent literature highlights a shift towards student-centered and project-based learning methods in STEM education [2]. Project-based learning (PBL) has been shown to enhance critical thinking, problem-solving, and teamwork by engaging students in real-world problem solving. Interdisciplinary approaches that incorporate elements of design thinking, collaborative learning, and experiential learning are increasingly recognized as effective strategies for bridging the gap between theory and practice.

Several studies have also explored the integration of digital tools and AI in education. For instance, adaptive learning systems and intelligent tutoring systems have been applied to customize learning experiences and provide real-time feedback [3, 4]. Large language models, with their ability to generate and parse complex textual information [5], are emerging as promising tools for transforming educational content, particularly in fields with steep learning curves like robotics.

The convergence of large-scale language modelling (LLM) and education has catalysed transformative advances in personalized learning, instructional efficiency, and educational equity [6]. Tools like ChatGPT assist educators in generating lesson plans, cross-disciplinary materials, and automated grading rubrics, reducing administrative burdens [7]. Other studies have discussed in depth the collaboration between teachers and AI, emphasizing the importance of teachers’ pedagogical expertise when using AI tools [8].

This paper explores how such an approach can be effectively applied to robot design technology courses for non-robotics majors, focusing on three core aspects: knowledge-level support, visualization structure support, and case-based learning support. This study demonstrates that integrating these elements into a cohesive, iterative teaching process not only improves theoretical comprehension but also fosters critical thinking, practical problem-solving, and creative innovation. Building on this foundation, the following sections introduce the large language model-inferred approach, which offers dynamic and personalized support for teaching robot design technology to non-specialist students.

2. LLM-inferred method for Teaching Arrangement

Large Language Models (LLMs) are deep learning-based algorithms that process and generate natural language through extensive training on diverse text data. At their core, LLMs utilize the Transformer architecture, which enables strong generalization, multi-task processing, and applications such as text generation, translation, and question-answering. The large language model-inferred approach leverages these capabilities to enhance teaching by providing dynamic, interactive support. Specifically, LLMs rely on:

- Large-Scale Pretraining: Enabling them to acquire extensive domain knowledge and generate contextually relevant explanations.
- Transformer Architecture with Self-Attention: Allowing the model to break down complex content into coherent, manageable units.
- Contextual Understanding and Adaptive Generation: Tailoring responses to the student's background to make technical knowledge accessible.

➢ Feedback-Driven Adaptation: Continuously refining explanations based on real-time student feedback.

By integrating these principles, the LLM-inferred approach deconstructs complex robotics topics into modular knowledge units, fostering structured and flexible learning. This AI-driven method actively engages students in an iterative learning cycle, where concepts are introduced, tested, and refined with AI assistance. LLMs support students by:

➢ Enhancing Reasoning Skills: Providing step-by-step explanations and logical breakdowns of robotics concepts.

➢ Enabling Visualization: Generating diagrams, 3D models, and simulations of robotic structures and movements.

➢ Facilitating Case-Based Learning: Offering real-world case studies, scenario analysis, and problem-solving exercises.

➢ Providing Adaptive Feedback: Identifying learning gaps through performance analysis and refining instructional strategies accordingly.

For non-robotics majors, this approach simplifies complex robotics concepts into manageable modules, delivering tailored explanations that clarify theoretical principles, such as system architecture, control algorithms, and sensor integration. It seamlessly integrates theoretical and practical learning, guiding students from abstract concepts to hands-on applications, such as programming simulations and real-world robotics case studies.

The teaching arrangement of the LLM-inferred method is illustrated in Figure 1. As shown in the diagram, the approach begins with dynamic theoretical instruction and progresses through visualization and case-based application, ultimately forming a continuous feedback loop that refines the learning process. This integrated cycle ensures that students can effectively transition from abstract concepts to practical applications while receiving personalized support throughout their learning journey. This framework not only enhances comprehension but also fosters adaptability in students, allowing them to apply their knowledge effectively in evolving technological contexts. The subsequent sections will explore each stage of this process in greater detail, highlighting the specific techniques and tools employed at each step.

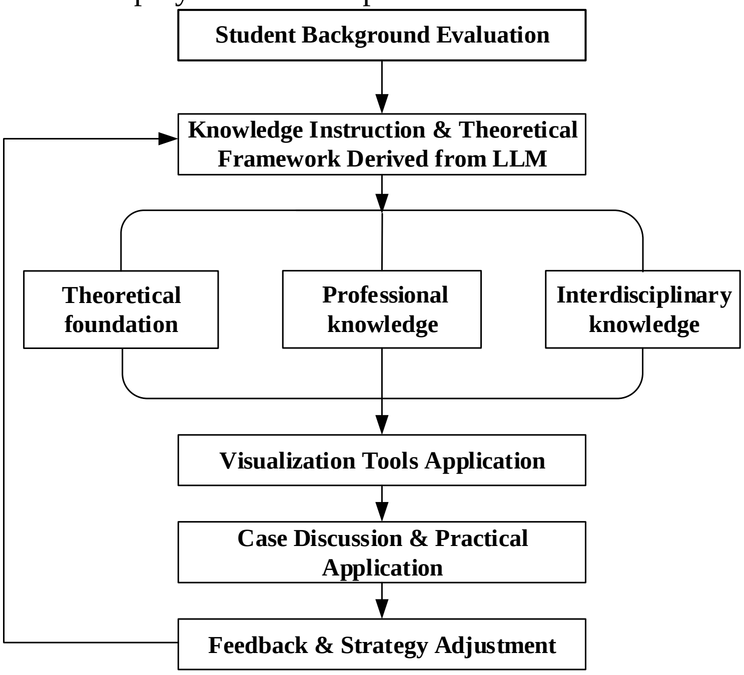

Figure 1: Teaching arrangement with Aides of LLM

3. Teaching Model Design with Aides of LLM

3.1. Reasoning assistance for basic knowledge

Non-robotics students often lack relevant professional background. The large language model can explain the abstract theories in robot design (e.g., kinematics, control theory, etc.) in layman's language to reduce the learning difficulty. Through natural language generation technology, the model can transform specialized terms and complex formulas into easy-to-understand descriptions and examples. The model can break down the complex knowledge system into multiple small modules and explain each part step by step. In this way, students can gradually build up an overall understanding of robot design technology, starting from the most basic concepts and then gradually transitioning to higher-level applications. The large language model supports real-time interaction, allowing students to ask questions and receive detailed explanations and examples at any time during the learning process. This instant feedback mechanism helps clarify queries in a timely manner and ensures that students do not fall behind due to knowledge blind spots. Based on students' questions, learning progress, and understanding, the model is able to recommend suitable learning materials, practice questions, and examples, making the learning process more personalized. By dynamically adjusting the content and difficulty of teaching, it helps students master robot design-related knowledge more effectively. Robot design technology involves multiple disciplines (e.g., mechanics, electronics, computer science, etc.), and the large language model can integrate the knowledge of various disciplines and present it to students in a coherent way, helping them understand how the knowledge of different disciplines is related to each other in robot design so as to build a comprehensive knowledge system.

3.2. Visualized comprehension for robotic mechanism

Large language modelling can be combined with image generation techniques to transform abstract robot design principles into visual illustrations such as flowcharts, structure diagrams, and 3D models. This visualizes complex concepts such as kinematics, control systems, and sensor layouts, helping students more easily understand the functions and interactions of robot parts. By integrating natural language descriptions with visual elements, the models can generate interactive learning resources, such as animations and dynamic simulations, which demonstrate the robot's motion and behaviour in real-world work. This multimodal presentation enables students to observe and understand abstract concepts in dynamic contexts, thus deepening their understanding of robot mechanisms. During the learning process, students can ask specific questions related to the robot mechanism, and the model not only provides textual explanations but also automatically generates corresponding visuals (e.g., schematics or videos) to demonstrate complex concepts in an intuitive way. Such personalized visual answers can provide in-depth explanations to students' questions and reduce the difficulty of understanding. Overall, through automatic diagram generation, interactive visual resources, and personalized visual answers, the large language model greatly lowers the threshold for non-robotics students to understand complex robotics mechanisms and improves teaching effectiveness.

3.3. Case learning support

The large language model can intelligently filter and recommend relevant real-life case materials based on course topics and student backgrounds. It can not only extract successful robot design cases from a large amount of literature and data but also generate case descriptions suitable for beginners to understand so that students can visualize the application of theory in practice. The model can construct virtual case scenarios and demonstrate how robot design works in different environments through situational simulation. By analysis of the case scenarios in detail, students can understand the reasons behind each design decision and the actual effects, further stimulating their interest in solving real-world problems. In the case study process, the large language model can ask guiding questions to encourage students to think and discuss actively. For example, it can break down the key technologies, problem challenges, and innovative solutions in the case and guide students to think about how to improve the design solution. This interactive discussion model helps develop students' critical thinking and innovation skills. The model is able to analyse the case from multiple perspectives, including technical implementation, cost-effectiveness, and market application. By synthesizing this information, students can not only see the combination of theory and practice but also learn how to balance various factors in real projects and form a more comprehensive engineering mindset. Overall, the large language model provides a rich, interactive, and personalized case learning platform for non-robotics students through intelligent recommendation, scenario simulation, guided discussion, and multi-perspective analysis, effectively reducing the difficulty of case understanding and improving their ability to apply theories to practice.

3.4. Teaching performance validation from feedback

The large language model is capable of integrating data from classroom interactions, online quizzes, assignment submissions, and discussion feedback. By automatically analyzing student responses, questions, discussion content, and affective tendencies, the model can accurately capture student performance in terms of knowledge acquisition, depth of understanding, and application skills. Based on the collected feedback data, the model can automatically generate assessment reports to diagnose students' weaknesses in the learning process. For example, if there is a general misunderstanding of a certain concept, the model will suggest the teacher adjust the teaching strategy or provide supplementary materials so as to realize personalized teaching. For objective questions, programming tasks, or open-ended problems, the large language model can automate grading with pre-trained scoring criteria and provide detailed suggestions for improvement. This instant feedback helps students understand their shortcomings and conduct targeted review and practice. The large language model forms a closed-loop iterative feedback system by analyzing student responses, quiz results, and discussion content. For instance, if a majority of students exhibit misunderstandings in control theory, the model flags this issue, prompting instructors to provide additional examples or supplementary materials. Similarly, feedback from interactive visualization sessions can guide improvements in the clarity of diagrams and simulations, while insights from case discussion assessments help refine the selection of real-world examples. This targeted feedback loop ensures that teaching strategies are continuously optimized to meet students' evolving learning needs. Through the above mechanism, the LLM can achieve automatic verification and feedback of teaching performance, help teachers pinpoint problems in teaching, and at the same time provide students with personalized, real-time learning improvement suggestions, which ultimately improves the overall teaching effect.

4. Conclusions

With advancements in technology and interdisciplinary research, the large language model-inferred approach for teaching non-robotics major students robot design technology holds promising prospects for further development. By integrating artificial intelligence, real-time feedback, and adaptive learning systems, future iterations of this approach are expected to provide more personalized and scalable learning experiences. These enhancements will enable educators to continuously refine course content and teaching strategies, ensuring that the curriculum remains aligned with emerging trends and meets the diverse needs of students across various disciplines. The application of the large language model-inferred approach in teaching robot design technology represents a significant step forward in addressing the challenges associated with traditional technical education for non-specialist students. By integrating knowledge-level support, visualization structure support, and case-based instruction, the proposed teaching model offers a comprehensive framework that bridges the gap between abstract theory and practical application.

Through systematic knowledge instruction, interactive visualization, and the analysis of real-world cases, students gain a deeper understanding of robot design principles and develop the necessary skills to apply this knowledge effectively. Moreover, the incorporation of a continuous feedback loop ensures that the teaching process remains adaptive and responsive to the evolving needs of students. As robotics continues to permeate diverse fields, equipping non-specialist students with the ability to understand and engage with robot design technology is increasingly important. The large language model-inferred approach, with its focus on structured reasoning and iterative learning, not only improves student outcomes but also fosters a culture of innovation and practical problem-solving. Future research could further explore the long-term impacts of this teaching model and its potential applications in other interdisciplinary domains.

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