Unibotics: Enhancing robotics education through intelligent tutoring system, ROS and realistic simulations

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Abstract: Unibotics is an online web platform designed to facilitate hands-on learning in robotics through interactive exercises and realistic simulations. It provides higher education students with access to a wide set (26) of robotics challenges, enabling them to develop practical skills in robot programming, sensor processing, robot control and autonomous behavior. The platform is widely adopted in academic settings to support courses in mobile robotics, service robotics, industrial robotics, computer vision and AI driven robotics, offering a scalable and accessible environment for experimentation and skill acquisition. It is based on ROS 2 middleware, the de facto standard in robotics, and two open source simulators: Gazebo and O3DE. Each exercise is solved on a single webpage that shows the robot in the simulated world for the corresponding robotics challenge. The students also edit and run the source code of their solution (in Python or C++) inside that webpage.

To enhance the learning experience, Unibotics is currently integrating an *intelligent tutoring system* powered by a Retrieval-Augmented Generation (RAG) architecture. This AI-based tutor leverages the complete user documentation of the Unibotics exercises, which includes theory explanations and hints, to provide students with accurate, context-aware guidance. When students pose questions in an online chatbot in each exercise webpage, the system retrieves relevant information from curated sources and generates responses grounded in the specific content of the exercise they are working on. This ensures that the assistance provided is not only technically correct but also pedagogically aligned with the intended learning outcomes.

This approach offers several advantages over general-purpose AI tools. External AI systems may produce hallucinated, overly complex, or contextually irrelevant answers that can mislead students or hinder their understanding. In contrast, the Unibotics tutor ensures that responses are precise, relevant, and tailored to the educational context. It supports students in navigating challenges, clarifying instructions, and deepening their conceptual understanding without deviating from the structured learning path defined by the course.

This contributes to a more inclusive and effective educational experience, particularly in large or remote learning settings where direct instructor support may be limited.

In summary, Unibotics represents a significant advancement in robotics education by combining state of the art robot simulation technologies with intelligent, context-aware tutoring. Its innovative use of AI not only enhances student engagement and autonomy but also reinforces the pedagogical integrity of the learning process.

Keywords: robotics education; hands-on learning, simulation technologies; intelligent tutoring system; scalable and accessible.