Unmanned Robotic Online Laboratory with an Intelligent Cloud Teacher

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Abstract: One-on-one student-instructor communication is essential in many aspects for science and engineering education. Especially under and post COVID-19, individual student-instructor interactivity becomes increasingly precious yet growingly difficult. To address this issue, this poster paper develops a so-called “cloud teacher”, which is an intelligent conversational agent for answering the questions from students in building and manipulating their robots online. The basic underlying idea is to train the agent by utilizing open-source artificial intelligence tools from Google’s DeepMind, such that the agent can understand and answer the questions raised by students in making their robots online. Specifically, distinct features of cloud teacher include: 1) Provide instant textual answers to students’ questions regarding robot assembly and computer programming (Arduino and SolidWorks: Two most common software in robot control and 3D printing). 2) Supply video demonstrations for helping students in building and manipulating their robots. 3) Automatic assessment of students’ online lab performance on controlling their robots. 4) Personalized quizzes based on big data analytics of students’ historical questions and performance. Based on the above features, an unmanned robotic online lab has been constructed with 11 sets of real robotic arms, controllers, touchable monitors and corresponding software. The approach of AI-powered conversational agent has demonstrated its effectiveness in 4 engineering courses with more than 300 students. Furthermore, we collaborated with an oversee university, and applied it in the distant robotics education with 50 students from U.K. This method has a high potential to be explored across different disciplines and countries for virtual experiential learning in the new normal.

Keywords: Artificial Intelligence in Education; Experiential training; Online teaching; Education in Robotics;

1. Introduction

Experiential learning is indispensable in knowledge and skills acquisition in many subjects. It includes a laboratory hands-on procedure which enable students unique chance for personal and practical manipulation of materials and facilities to acquire and enhance the understanding on concepts, problem analysis-evaluation-solving skills (NSTA, 2007). Experiential learning could be found in many discipline and subjects, like physics, chemistry, medicine, mechanics, robotics, etc. Face-to-face laboratory has been developed along with the procedure of development of science and technology such that the concepts introduced in lectures and books could be enhanced and reinforced by hands-on training (Diwakar, S, 2023). However, one nonnegligible question of face-to-face laboratory is its physical and economic constraints, especially under and post the period of COVID19.

To overcome these constraints, online laboratory is proposed and displayed its vitality especially in last two decades. Online laboratory could be roughly classified into two categories: virtual laboratories and remote ones (Tzafestas, C. S., 2006). Each category has its own advantages: The former tends to supply with less realism but more scalable and easier in maintenance, while the latter is more practical and error-prone. In teaching robotics, we focus on using online laboratory to meet the strong demands of students in operating and manipulating the real robots in practice. The effectiveness of online laboratory has been shown compared to traditional face-to-face laboratory by evaluating the students experiences in online laboratories in some science courses (Rowe, R. J., 2018). A remotely online accessible swarm robotics research testbed, called Robotarium is proposed for multi-robot research facility (Pickem, D., etc. 2017). A hybrid online laboratory model is provided by merging both categories of online labs and show how it can leverage the advantages of both type of labs (Rodriguez-Gil, L., 2016, and Andujar, J. M., 2010).

This poster paper displays how we developed an unmanned robotic lab (Section 2.2-2.3) and its impact on teaching and learning (Section 2.3).

2. The Intelligent Cloud Teacher

2.1 Main Development Procedure

The whole process of the project development can be generally divided into four parts: The first part focuses on training the intelligent agent with a database of fundamental knowledge of Mechanical Engineering related to the U.S. Mechanical Engineering Syllabus for Mechanical Engineering Graduates. The second part is concerned with the training of the intelligent agent regards to a database of Arduino programming. The third part aims to train the intelligent agent with a database of VEX hardware assembling. In the last part, a mobile APP will be developed and implemented in an online robotic laboratory (see Figure 1).

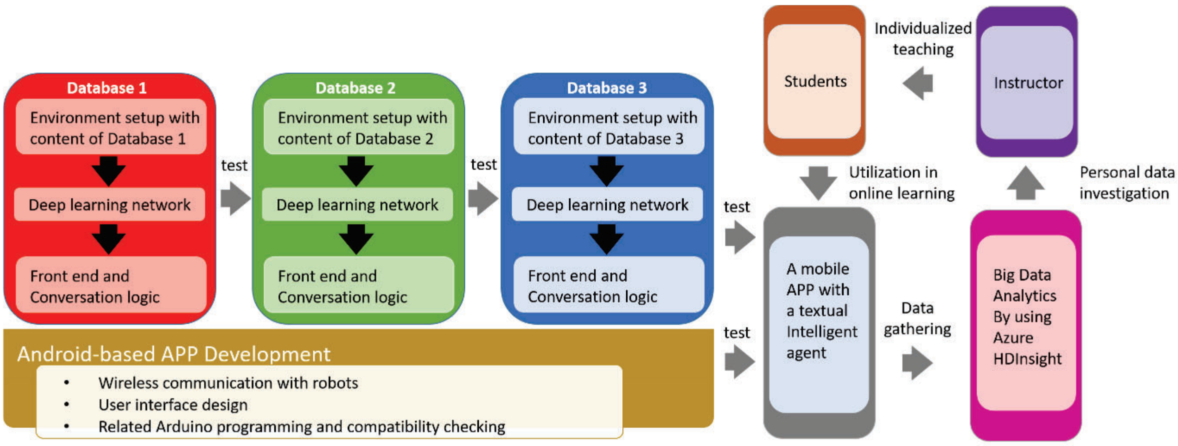
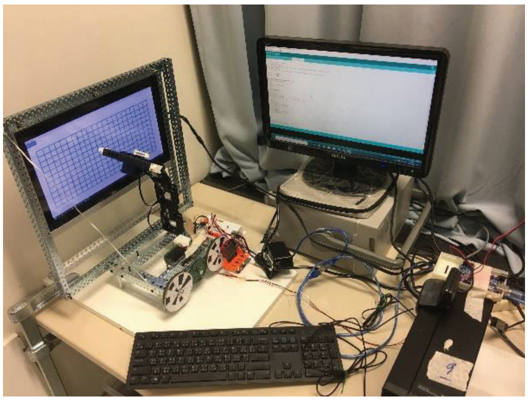


Figure 1: Development pipeline of the proposed smart agent

2.2 Construction of Unmanned Robotic Online Lab

The basic idea is that we combine the flipped lab with a real online lab, so students can get access and conduct experiments in an online mode. An online robotic lab can be constructed based on our robotic lab with real robots and computers. The conventional robotic lab can be transformed to an online lab thanks to the remote control technique, where students could use their personal computers in distance to control the computers in the lab, further tuning and controlling the robot in real time. On the other hand, this project combines with flipped lab, which allows students to learn from videos of lab instructions before each online lab.

As a result, more time and efforts could be devoted into problem solving and students-instructor interaction in synchronous online lab. students raise their hand by flashing their lights, it is a quite effective way in communication in the lab. So we have extra benefits by avoiding healthy problems and safety problems compared to conventional labs. To build the online lab, we developed different hardware and software components: First, we assembled the robotic arms, controller, drawing panels for students (See Figure 2). In addition, we developed corresponding software, like, Arduino-based programme to control the robotic arm. Most importantly, we installed remote control software, which makes the programming and controlling of robots possible. Students can use remote control software to manipulate their robots in distance.



(a) (b)

Figure 2: (a) One set of remote controllable robotic equipment with sensors and a touchable drawing panel. (b) Ten sets of remote controllable robotic facilities.

2.3 Impact on Improving the Quality of Education

The monitoring data have been collected by the evaluation methods and illustrates the usefulness of this work:

1) Rate of positive feedback is 93.2% in the Survey on the experience of using the cloud teacher towards the end of the course UGEB2303 Robots in Action.
2) Rate of positive feedback is 82.9% in the survey on the unmanned robotic online lab towards the end of the course UGEB2303 Robots in Action.
3) Rate of positive feedback is 100% in focus group interview with a small group of volunteer students of the course UGEB2303 Robots in Action.
4) Rate of positive feedback is 84.6% on the course website and small group forum.

Note that the most remarkable achievement of the proposed cloud teacher is to provide a new way through which students can get hands-on training and achieve the desired outcomes of lab sessions online. In addition, it goes beyond the traditional face-to-face robotic laboratory and supplies with intelligent chatbot in Arduino programming, real-time automatic assessment of students lab performance and personalized quizzes based on big data analytics of students' historical questions and performance.

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