AI-Powered University: Design and Deployment of Robot Assistant for Smart Universities

Thanh-Hiep Nguyen, Duy-Nhat Tran, Doan-Linh Vo, Van-Hung Mai, and Xuan-Quy Dao
Eastern International University, Vietnam
Email: {hiep.nguyen.set15, nhat.tran.set15, linh.vo.set15, hung.mai.set15, quy.dao}@eiu.edu.vn

***Abstract*—This study presents four robot systems that utilize artificial intelligence techniques to assist students, teachers, and staff in the university. The goal of the assist robot systems is to reduce workload and enhance the effect in teaching and learning as well as improve the learning environment at university. The four robot systems including virtual assistant, telepresence, guide, and delivery robots were proposed and developed. In online learning, the virtual assistant robot supports students and teachers in learning and teaching by an interactive and informative learning environment and consequently maximizing learning outcomes. The telepresence robot allows students to follow the classroom at home or hospital in the case that students are unable to attend classes due to special reasons (Covid-19 pandemic, illness). The guide robot was developed as a physical robot which places or moves in the small range at the library, administrative building, restaurant, and residence to provide information such as book searching, freshman quiz, restaurant menu, events, and places. Finally, the delivery robot aims to deliver documents, books, and food/drink to students and teachers on the university campus in the motive of improving the quality of life and services. The motivation of this paper is highlighting the benefits of using robots in the development of smart-university. Experiments at Eastern International University showed that students are interested in the four robot systems and these robots enhance student engagement in learning and campus activities as well as significantly reduce the teacher's workload. The virtual assistant, the telepresence, and the delivery robots gave great benefits in tackling the effect of the COVID-19 pandemic while the guide robot created exciting experience and productive outcomes for new students and visitors.**

***Index Terms*—mobile robot, guide robot, virtual assistant, telepresence robot, delivery robot, smart campus**

I. Introduction

The smart-university campus may comprise smart buildings, campus smart grid, learning environment, water and waste management, parking, voting, access control, etc. Improving learning environment is one of the important strategies to maximize learning outcomes.

Recent advance in robotic research enables the robot to assist humans in many ways. The study of virtual assistant (chatbot) implemented in the smart university campus was conducted and presented in previous works [1]-[5] and our previous works [6], [7]. Presented in [1], the authors introduced a chatbot for university assisted FQAs. Besides, the proposed chatbot can handle an efficient and precise feed-back for any query by utilizing the dataset of FAQs applying Artificial Intelligence Markup Language (AIML) and Latent Semantic Analysis (LSA). Meanwhile, in [2] the authors conducted deep learning utilized in a self-driving car to construct a virtual assistant that assists the newcomer to get direction to their college. The investigational study at Georgia State University (GSU) indicated that GSU dedicated students appointed to the treatment revealed superior achievement with pre-enrollment requests. The greater portion of enrolling on time was 3.3 percentage points was recorded. In another study [3], the authors presented a chatbot to assist students in their campus life via informative guidance and services. In another study [4], the author affords is to construct a self-directed virtual assistant health tutor that learns from professional exhibition to communicate with patients via SMS. In [5] a digital assistant was introduced to assist students in texting their scholastic coursework. In the previous work [6], we proposed a virtual assistant to help teachers, learners, and administrators in learning, teaching, and management in online learning. Our virtual assistant [7] focused on reducing the teacher's workload in creating video lectures and maximizing student engagement to maximize learning outcomes.

Physical robots are also implemented in the classroom to enhance student engagement, learning experiences, and outcomes. Study results in [8] utilized a robot in an English learning classroom. Five types of cooperation models between lecturers and robots were considered including (1) storytelling model; (2) Q&A model; (3) Cheerleader model; (4) Let's act model; (5) Pronunciation leading model. Five models of the robot were intended to assist the lecturer/trainers in lecturing and encourage students to engage in learning activities. These results indicated that a dominant portion of students in the evaluated classes had a positive attitude to this robot, and had a vast curiosity in the robot's ability. In [9], the author introduced an example of utilizing robotic telepresence devices in synchronous hybrid learning classes for the Educational Psychology and Educational Technology Ph.D. program to find a single best solution. In order to investigate the utilization of telepresence robots for the distant presence of university-level courses, Fitter *et al.* [10] assessed student attending throughout three separate phases in three diverse methods:

Manuscript received May 17, 2021; revised November 26, 2021.

doi: 10.12720/jait.13.1.78-84

(1) in person, (2) via state-of-the-art university Distance Learning Tools (DLT), and (3) via a telepresence robot. The resulted outcomes demonstrated that students experienced more present, self-aware, and communication when using a telepresence robot than when utilizing DLT. Additionally, the instructor recorded that telepresence would be advantageous to DLT utilization. The telepresence robot was introduced that mobile telepresence [11] is a system supplying cooperative audio and video conferencing and navigating for a remote circumstance [12]. In [13], the authors suggested an idea for the ill student by means of the assist of mobile telepresence robots in the classroom from home or from the hospital to study or get in touch with contacts. The consequences indicated that the ill student can develop communally as in school in the circumstance that the presence at school is impossible for days.

In [14], the author developed a guide robot that can autonomously guide people throughout the university campus. By using Differential Global Positioning System (DGPS) and Dead-Reckoning using the encoders mounted on its wheels, this robot is able to evaluate its location and guide people around the university campus. Another work in [15] the author built TritonBot, a long-term autonomy robot working as a building receptionist and a tour guide. In order to achieve this task, TritonBot can recognize people's faces, talks to them, and guides people to the labs and facilities in an office building. Pepper is one of the most popular social robots, and Chowdhury *et al.* [16] presented the design and evaluation of the university guidance robot based on the social guide Pepper. They obtained an amazing result that demonstrated the university guide robot successfully evoked nurture, fellowship, and recreation among students.

Furthermore, a delivery robot is a kind of self-driving car which is used to deliver food, drinks, parcel, and another item to the customer. In 2016, the first delivery robot, Domino's Robot Unit, was used to deliver pizza. In the same year, Starship launched their 40-pound delivery robot and partnered with Domino's to deliver pizzas. Now, the autonomous delivery robot has ben evolving rapidly and there are some commercial small size delivery robots such as Starship, R2-Nuro, Scout-Amazon, Eliport, Serve-Postmates. These robots are built based on a combination of artificial intelligence (machine learning and deep learning) and sensors technologies to on sidewalks and navigate around obstacles. Furthermore, they can automatically change their batteries with no human help. So, they can operate independence with human. Starship launched their delivery robot in some university such as Bowling Green State University, George Mason University, Northern Arizona University, University of Mississippi, etc.

Inspired by the above-mentioned studies, in this study, we focus on leveraging AI to implement four robot systems in the smart university campus to improve the experience, learning outcomes, and environment.

The rest of this paper is organized as follows. Section II introduces the background of each robot system concerned. Section III describes four robot systems: virtual assistant, telepresence robot, guide robot, and delivery robot. Section IV is experimental results where the four robot systems were implemented at Eastern International University (EIU) Campus. Section V are some conclusions and perspectives on future works.

II. Background

In this section, we introduce a brief four robot systems as well as the core technologies which are used to apply for designing and implementing four robot systems for smart universities.

A. *Virtual Assisant*

There are some virtual assistants in Fig. 1 such as Siri (Apple), Google Assistant, Bixby (Samsung) and Alexa (Amazon) that these virtual assistants can communicate with human via text and voice. These virtual assistant help human in finding information, answering human command, guiding human in their life. To build them, the core technologies are used such as natural language processing (automatic speech recognition, speech synthesis), natural language understanding, natural language generation, and image processing which are developed based on AI techniques such as machine learning, especially deep learning.

Figure 1. Virtual assistant examples.

In our approach, the virtual assistant is a part of online learning platform. There are some virtual assistants such as virtual question/answering assistant, virtual research assistant, virtual social agent assistant and virtual agent assistant which improve teaching and learning ways by reducing teacher's workload and supporting students.

B. *Telepresence Robot*

Figure 2. Telepresence robot examples.

Fig. 2 introduces some telepresence robots which are built based on a mobile robot combined tele-conference system. The mobile robot can move according to the predetermined item or people. In basic cases, we don't need a mobile robot, we only need tele-conference which maybe tablet or smart phone. Note that the core technologies are mobile robots which can follow people movement and communication techniques.

In reality, the telepresence robots can help students who are unable to get to the classes or old people in daily activities.

C. Guide Robot

Fig. 3 are some guide robots deployed in reality. They usually contain a touch screen which displays information and interact with human. In basic cases, they are tablet, desktop and laptop. Their core technologies are communication system and usually humanoid robot. The social robot Pepper (big robot in Fig. 3) developed by Softbank Robotics is one of the most famous guide robots.

Figure 3. Guide robot examples.

The guide robots are social robots which interact with people in different environment such as receptionist in hotels, restaurants, companies or tourist guide at museum. Especially, the humanoid robot usually uses as teacher at classroom in order to improve learning environment.

D. Delivery Robot

In Fig. 4, we have some delivery robots such as Starship, Scout-Amazon, Serve-Postmates and Nuro. The Startship is one of the first autonomous delivery robots deployed at universities. And these robots become more popular in Covid-19 pandemic because it allows people to be out of physical contact.

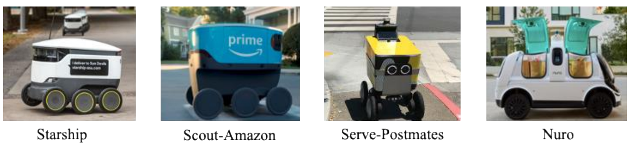

Figure 4. Delivery robot examples.

These delivery robots are built based on computer vision technologies similarity to self-driving cars. The delivery robots use feature detection of edges and mapping techniques to determine the suitability of navigable terrain. The robots are equipped with a sensor suite that includes cameras, GPS, ultrasonic sensors, radar.

III. Design of Four Robot Systems

In this section, we introduce four robot systems designed and implemented by Human-Machine Interaction Team (HMI), FabLab and ERIS Lab at EIU. The virtual assistant is built by HMI; and the telepresence robot and guide robot are developed by FabLab while the delivery robot is construct by ERIS Lab.

Fig. 5 shows the architecture of robot which consists four layers such as robot hardware, robot software framework, robot application programming interface and service application. Note that each function block is designed corresponding to one of four robot systems: virtual assistant, telepresence robot, guide robot and delivery robot. ROS, OpenCV, Keil C and Python were used to build robot software.

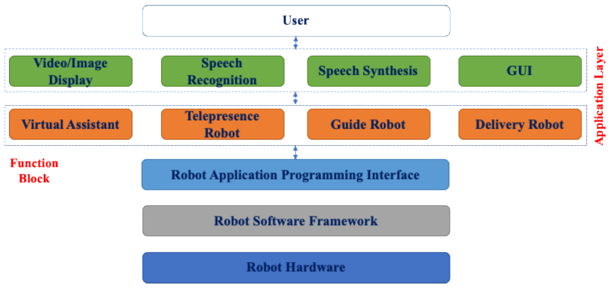

Figure 5. Robot architecture layers.

Next, we introduce a design of four robot systems for smart universities which are based on AI technologies.

A. Virtual Assistant

Virtual Assistant is a bot in online learning platform which provides course information and knowledge. Virtual assistants are deployed in the classroom and in the laboratory. Fig. 6 introduce a virtual assistant architecture which shows a relationship between virtual assistant and users in classroom, laboratory and online learning platform. As above mentioned, the virtual assistant is built based on the natural language processing, natural language understanding and natural language generation.

In our context, we design three core virtual assistants. First of all, a virtual QA assistant answers student questions in course or FQAs. Secondly, a virtual research assistant helps student to seek research information in laboratory or internet. These two virtual assistants are designed to support students. Finally, a virtual assistant is designed to automatically create video lecture with teacher's voice and face. These three virtual assistants can take over the teacher's routine task, frees up teacher's time, enabling them to focus on student guidance and one-to-one communication.

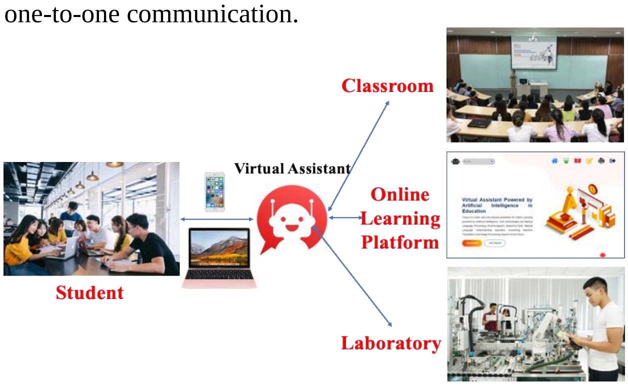

Figure 6. Virtual assistant architecture.

B. Telepresence and Guide Robots

In our approach, the telepresence robot and the guide robot have same robot hardware but each robot has software designed to perform specific functions. These robots are equipped microphone and speaker to communicate with people in university campus.

Fig. 7 shows the telepresence robot architecture that students follow courses at home or hospital. Especially, in the afford of tackling the effect of COVID-19 pandemic, tele-education is an optimal solution to avoid the disruption in learning progress. In tele-education, telepresence robot is one of the most efficiency because the previous results showed that students experienced more present, self-aware, and communicative when using a tele-presence robot than when utilizing distance learning tools [10]. Note that telepresence robot is able to change the location and the direction to follow teacher or another student. This allows students to follow lecture in the classroom through camera, ask teacher or talk to their friends.

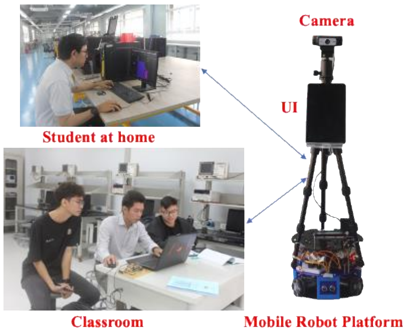

Figure 7. Telepresence robot architecture.

Fig. 8 shows a design of guide robot which helps people to seek information about the university campus. This design focuses on information display about library, administrative center, and canteen. This robot allows students to connect to library, administrative center, canteen and residence. This robot is equipped touch tablet to interact to people. We also communicate to robot by text and voice which is built similarity to the virtual assistant.

Figure 8. Guide robot architecture.

C. Delivry Robot

Fig. 9 shows a delivery robot architecture. In this design, the delivery robot is designed to deliver food, drinks, parcel and other items from library, administrative center, canteen to students, teachers, and staffs. User call the delivery robot through a mobile app or a web app.

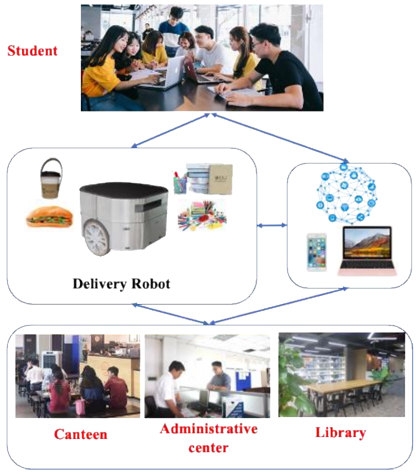

Figure 9. Delivery robot architecture.

IV. Experimental Results

In this section, we show four robot systems launched at EIU. The Human-Machine Interaction (HMI) Team developed virtual assistant, telepresence and guide robot software, while FabLab and ERIS Lab made the telepresence and guide robot hardware and delivery robot hardware, respectively. EIU places at “New City - Binh Duong”, Vietnam as shown in Fig. 10.

Figure 10. Smart University Campus: Eastern International University.

Table I shows four robot systems which are setup in EIU Campus. The virtual assistant, telepresence robot and delivery robot are implemented in classroom, administrative building, library, canteen, university residence. While the guide robot is implemented in administrative building, library, canteen and university residence. Furthermore, the virtual assistant and the telepresence robot are also implemented in home that allows student to follow course in classroom or university activities.

TABLE I. Deployment of Four Robot Systems on EIU Campus

Campus	VA	TGR	GR	DR
Classroom	x	x		x
Administrative Building	x	x	x	x
Library	x	x	x	x
Canteen	x	x	x	x
University Residence	x	x	x	x

A. *Virtual Assistant*

The recent research results of Automatic Speech Recognition (ASR) and Text to Speech (TTS) systems using deep learning neural network enables the deployment of real applications with great accuracy and tend toward human performance. With lot of success of AI in education, teachers have already started working together with virtual assistant for the best learning outcomes for their learners [6], [7].

We introduce a text and voice virtual assistant for online learning platform which helps teacher to create video lecture and provide course information to students via chabot [6]. Note that in addition to this virtual assistant, we also develop many virtual assistants to assist students in other aspect such as environment monitoring, bus time guide, EIU campus map guide, etc. These virtual assistants are developed by HMI at Eastern International University.

In this section, we focus on introducing a video lecture generation based on AI technique which is one of core technologies to build the virtual assistant [7]. In order to create video lecture, teacher's voice and face generation are created by AI system in online learning platform. To achieve this work, we use real time voice cloning to clone teacher's voice and speech-drive face to generate teacher's face.

Fig. 11 introduces a video lecture generation by AI system [7] where video lecture contains two parts: 1, Slide - PowerPoint presentation (format pdf); 2, Talking Head Video with teacher's voice and face. The video lecture is generated based on text to speech and speech drive face where teacher's speech is generated from transcript and teacher's face is generated from teacher's speech. Fig. 11 also shows User Interface of our online platform where the video lecture and chatbot are built based on AI technologies to enhance student supports.

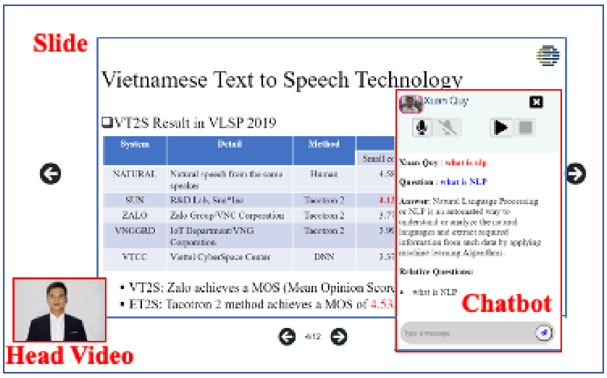

Figure 11. Online learning platform with virtual assistant.

B. *Telepresence and Guide Robots*

In the first time of COVID-19, we use remote learning tool based on tablet and smart phone as shown in Fig. 12. This is the simplest way to achieve remote learning.

Since the previous results showed that the telepresence robots help students learning remotely to feel more a part of the class because the telepresence robots are preferable to distance learning tools for remote learning, and the students noted the robots' ability to keep them more engaged, expressive and self-aware [10]. Therefore, we design and launch our telepresence robot implemented in the classroom as shown in Fig. 13. Due to the effect of COVID-19 pandemic, students need to pursue their education from a distance. Hence, the students use this robot to view the lecture, ask questions during the lecture, and move around during breaks to talk to friends or teachers.

Figure 12. Remote learning in classroom.

Figure 13. Telepresence robot in classrom.

Fig. 14 shows the guide robot is at EIU Library where all students can ask about relevant information such as COVID-19, FQAs, book searching, freshman quiz, restaurant menu, events, and places, etc. By using a robot with two functions (tele-conference and guide) and based on a simple construction, we need short time to deploy these robots in university campus.

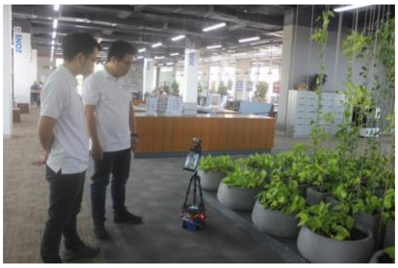

Figure 14. Guide robot at EIU library.

C. *Delivery Robot*

Fig. 15 shows the delivery robot developed by ERIS Lab. In the first time, this robot is built in order to deliver books around library. However, we develop this robot to become a delivery robot which deliver book, item and food/drink in EIU campus because of effect of COVID-19 pandemic. The student use web-app (website or mobile app) to order book, item and food/drink to be delivered anywhere in EIU campus within minutes.

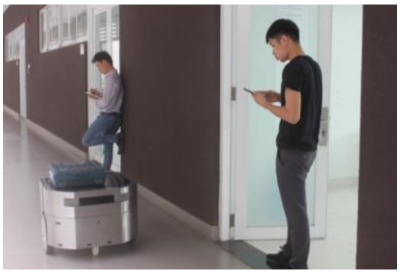

Figure 15. Delivery robot developed by ERIS lab.

V. Conclusion

This paper presented four robot systems launched at Eastern International University campus. The robot systems were built to improve learning environment as well as fight against COVID-19 pandemic. By using recent AI results, our robot systems enhance the quality of life and services in university campus. The virtual assistant improves learning outcomes in online learning. The telepresence and guide robots help students to learn in distance or connect information. The delivery robot brings a comfortable feeling from students in university campus as well as avoid close contact in Covid-19 pandemic. The experimental results showed that our approach is an effective way to guarantee learning environment in COVID-19 pandemic as well as bring a good learning experience.

In future work, we focus on a design of mobile robot platform which is compatible with both delivery robot and telepresence/guide robot.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

The three robot software systems: virtual assistant, telepresence robot, and guide robot are built by Human-Machine Interaction Team: Xuan-Quy Dao. While the guide robot hardware is made by FabLab: Thanh-Hiep Nguyen, Duy-Nhat Tran, Doan-Linh Nguyen, Van-Hung Mai. And the delivery robot is constructed by ERIS Lab under a project funded by Becamex IDC Corp.

Xuan-Quy Dao wrote the paper; all authors had approved the final version.

Acknowledgment

This research was supported by Eastern International University, Binh Duong.

The authors wish to thank Ngoc-Bich Le, Thi-My-Thanh Nguyen, Ngoc-Huan Le, Viet-Thang Nguyen, Bac-Bien Ngo, Xuan-Dung Phan, Duc-Canh Nguyen, Ngoc-Hay Nguyen, Thanh-Son Nguyen, Viet-Anh-Dung Cai and other students and lecturers of School of Engineering, Eastern International University who support our work.

References

[1] B. R. Ranoliya, N. Raghuwanshi, and S. Singh, "Chatbot for university related FAQs," in *Proc. International Conference on Advances in Computing, Communications and Informatics*, 2017, pp. 1525-1530.

[2] L. C. Page and H. Gehlbach, "How an artificially intelligent virtual assistant helps students navigate the road to college," *AERA Open*, vol. 3, no. 4, p. 2332858417749220, 2017.

[3] M. Dibitonto, K. Leszczynska, F. Tazzi, and C. M. Medaglia, "Chatbot in a campus environment: Design of LiSA, a virtual assistant to help students in their university life," in *Proc. International Conference on Human-Computer Interaction*. Springer, 2018, pp. 103-116.

[4] I. Gupta, B. D. Eugenio, B. Ziebart, B. Liu, B. Gerber, L. Sharp, R. Davis, and A. Baiju, "Towards building a virtual assistant health coach," in *Proc. IEEE International Conference on Healthcare Informatics*, 2018, pp. 419-421.

[5] O. Resch and A. Yankova, "Open knowledge interface: A digital assistant to support students in writing academic assignments," in *Proc. the 1st ACM SIGSOFT International Workshop on Education through Advanced Software Engineering and Artificial Intelligence*, 2019, pp. 13-16.

[6] T. Nguyen, H. Diep, B. Le, B. Ngo, and Q. Dao, "Design of online learning platform with Vietnamese virtual assistant," in *Proc. 6th International Conference on Intelligent Information Technology*, 2021 (accepted).

[7] Q. Dao, T. Nguyen, and B. Le, "AI powered MOOCs: Video lecture generation," in *Proc. the 3rd International Conference on Image, Video and Signal Processing*, 2021, pp. 95-102.

[8] Z. J. You, C. Y. Shen, C. W. Chang, B. J. Liu, and G. D. Chen, "A robot as a teaching assistant in an English class," in *Proc. Sixth IEEE International Conference on Advanced Learning Technologies*, 2006, pp. 87-91.

[9] J. Bell, W. Cain, A. Peterson, and C. Cheng, "From 2D to Kubi to doubles: Designs for student telepresence in synchronous hybrid classrooms," *International Journal of Designs for Learning*, vol. 7, no. 3, 2016.

[10] N. T. Fitter, N. Raghunath, E. Cha, C. A. Sanchez, L. Takayama, and M. J. Mataric, "Are we there yet? Comparing remote learning technologies in the university classroom," *IEEE Robotics and Automation Letters*, vol. 5, no. 2, pp. 2706-2713, 2020.

[11] M. K. Lee and L. Takayama, "'Now, I have a body' uses and social norms for mobile remote presence in the workplace," in *Pro. the SIGCHI Conference on Human Factors in Computing Systems*, 2011, pp. 33-42.

[12] A. Kristoffersson, S. Coradeschi, and A. Loutfi, "A review of mobile robotic telepresence," *Advances in Human-Computer Interaction*, vol. 2013, 2013.

[13] M. Schmucker, A. Reiswich, C. Pfeifer, V. De. Mey, and M. Haag, "Mobile robotic telepresence between hospital and school: Lessons learned," in *dHealth 2020–Biomedical Informatics for Health and Care: Proceedings of the 14th Health Informatics Meets Digital Health Conference*, IOS Press, 2020, vol. 271, p. 256.

[14] J. H. Lim and H. J. Kim, "Development of an autonomous guide robot for campus tour," *Transactions of the Korean Society of Mechanical Engineers A*, vol. 41, no. 6, pp. 543-551, 2017.

[15] S. Wang and H. I. Christensen, "Tritonbot: First lessons learned from deployment of a long-term autonomy tour guide robot," in *Proc. 27th IEEE International Symposium on Robot and Human Interactive Communication*, 2018, pp. 158-165.

[16] A. Chowdhury, A. Ahtinen, and K. Kaipainen, "'The superhero of the university' experience-driven design and field study of the university guidance robot," in *Proc. the 23rd International Conference on Academic Mindtrek*, 2020, pp. 1-9.

Thanh-Hiep Nguyen was born in 1997 at Ho Chi Minh City, Vietnam. He is currently finishing the B.S. degree in Automation and Control Engineering at the Department of Automation and Control Engineering, School of Engineering, Eastern International University, Vietnam. His research interests include automation and control engineering, robotics and mechanical design.

Duy-Nhat Tran was born in 1997 at Hue Province, Vietnam. He is currently finishing the B.S. degree in Automation and Control Engineering at the Department of Automation and Control Engineering, School of Engineering, Eastern International University, Vietnam. His research fields mainly focus on developing automation, robotics, computer vison, and self-driving-cars systems.

Doan-Linh Vo was born in 1996 at Binh Duong Province, Vietnam. He is currently finishing the B.S. degree in Automation and Control Engineering at the Department of Automation and Control Engineering, School of Engineering, Eastern International University, Vietnam. His research interests include autonomous robotics, self-driving-cars systems and industrial automation, and STEM.

Van-Hung Mai was born in 1995 at Nam Dinh Province, Vietnam. He is currently finishing the B.S. degree in Automation and Control Engineering at the Department of Automation and Control Engineering, School of Engineering, Eastern International University, Vietnam. His research interests include automation, manipulator robotics and smart industrial machines.

Xuan-Quy Dao was born in 1985 at Hai Duong Province, Vietnam. He is currently a Lecturer at the Eastern International University, Vietnam. He obtained the Ph.D. degree in signal processing and telecommunication at the French National Institute for Research in Computer Science and Control, France in 2014. He held both the M.S. and B.S. degrees in automation engineering from the Grenoble Institute of Technology, France, in 2010. His research interests concern signal processing, natural language processing, and machine learning (deep learning).