MEdOps - Medical Education with Emphasis on Robotics

Roman Hasko[a], Oleksandra Hasko[a], Christine Strauss[b] and Stefania Vyshnevska[c]

[a] *Lviv Polytechnic National University, 12, Stepan Bandera str., Lviv, 79000, Ukraine*
[b] *Faculty of Business, Economics and Statistics, University of Vienna, Universitätsring 1, 1010 Wien, Austria*
[c] *Ivan Franko National University of Lviv, 1,University Street, Lviv, 79000, Ukraine*

Abstract

This article considers a modern approach to a qualitatively new education of medical specialties, taking into account the latest advances in computer technology, particularly in the field of robotics. The MEdOps concept represents a synergy of medical education with information technologies that are already successfully used in the fields of computer science.

Special attention is paid to the emergence of such a new computer profession as DevOps. This is a universal specialist who ideally possesses a huge number of different technologies and platforms, a direct analogue of a modern highly qualified medical specialist, who must constantly improve his/her qualifications for effective work. One of the main focuses of the proposed approach is also the introduction of advances in robotics i.e. robots with remote human presence or telepresence in the process of education.

Keywords [1]

Tripled Learning, IoT, E-Learning, Telepresence, MEdOps, Robotics, ROS.

1. Introduction

Currently, the world is witnessing a significant increase in the most diverse learning methods, in particular, using applications of robotics, the Internet of Things (IoT), and augmented and virtual reality (AR/VR). This enables smart devices to share data over the Internet and improve the quality of learning.

People can offer and use learning services at any time, anywhere in the world. Special cloud-based web-oriented educational platforms [1, 2, 3] have been developed and a separate class of software - e-learning - has appeared.

Such systems are mainly built based on client-server architecture and use a traditional web browser to work with the web interface. Despite their absolute Internet and cloud technologies orientation, such systems are mostly not very effective when being used in a modern online or hybrid learning process. First of all, they require many displays instead of one and do not allow effective monitoring of students' independence and integrity.

Let's pay attention to the peculiarities of training in the medical field, in which modern mixed learning technologies using e-learning platforms can be especially effective. For maximum efficiency, it is considered appropriate to introduce specialized telepresence robots into the learning process for remote participation of students from various geographically distant positions with maximum immersion in the educational process.

An additional advantage of this is the practical experience of future specialists engaged in such activities and, as a result, a quick mastery of progressive telemedicine techniques in their future professional practice.

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EMAIL: r.hasko@gmail.com (A. 1); oleksandra.l.hasko@lpnu.ua (A. 2); christine.strauss@univie.ac.at (A. 3); hynda_stefani@ukr.net (A. 4).
ORCID: ORCID: 0000-0001-5923-6577 (A. 1); 0000-0003-4519-610X (A. 2); 0000-0003-0276-3610 (A. 3).

2. Background

Many years of experience in the creation and practical operation of educational systems of the e-learning class including gamification approaches, on the one hand, and development and training in the field of robotic systems, on the other hand, allow us to form visions and ways of solving modern problems in the educational field.

Special attention should be also paid to the emergence of a number of new professions in IT that consolidate existing technologies and computer platforms, for example in the form of DevOps.

DevOps is "a set of practices designed to reduce the time between making system changes and making changes to regular production while ensuring high quality" [8].

3. Related works

Robotics in the educational process. Modernity poses a number of challenges to the educational process, especially for university education [1] and various types of specialized training according to the concept of "lifelong learning". Additional restrictions of covid-19 accelerated the search for effective teaching methods [4]. Along with online education, the concept of blended learning appeared. For this, it is quite beneficial to apply the effect of remote presence using robots - telepresence robots [5].

Rehabilitation and Medical Robots. An example of the use of robotics in medicine can be a robot assistant for taking care of the disabled and the elderly. For example, Hayley Robinson, Bruce MacDonald, and Elizabeth Broadben [9] describe a job that should perform the functions of a nurse and provide assistance to people with reduced cognitive or physical capabilities of their body and, accordingly, may have various social difficulties. Daily assistance from robots with physical work could allow older people to be more independent and maintain their fitness on their own. Long-term research into the interaction of robots and humans can demonstrate the effectiveness and readiness of society for this. An example can be the Pepper robot and its activity in the cognitive and physical spheres [10, 11]. The conducted studies revealed that at this stage of the development of robotics, assistants are needed for the functioning of robots - people, currently robots cannot completely replace people, but they are able to help and give some new possibilities [11]. Robot-human interaction receives special attention when creating rehabilitation exoskeleton robots due to the direct contact of the exoskeleton with the human body [12].

Another example of the use of robotics in medicine is a rehabilitation robot from the University of Texas that helps people move their hands and is an example of a robotic system successfully implemented in the health care system. Such a robot should help people after a stroke or with neurological disorders in restoring the functioning of both hands and fingers [12]. In general, the interaction between a robot and a person is an important factor in the design of modern rehabilitation robots [13].

4. Proposed Approach

The proposed MEdOps concept is based on the following main technologies and platforms.

1. Triple learning, first proposed in [1]. It combines traditional learning with independent work and project work
2. The use of modular modern e-learning systems such as OpenEDX with integration into specific conditions of mixed learning
3. Robotics, in particular telepresence robots with extended functionality and partial autonomy due to AI

Let's consider all three parts mentioned above. The authors already described the concept of Tripled Learning earlier. Existing open software can be used to build the software and hardware robotics parts, taking into account a new approach to education, in particular in medicine. The term MEdOps, proposed for the first time, means the unification of both medical education and learning management systems

(LMS/ILMS) with an emphasis on DevOps, namely the use of existing and tested software in new configurations with the result of obtaining new products and improving the quality of education.

4.1. Concept of Tripled Learning

The modern educational process has various implementations. Often, along with traditional classical methods such as lectures, seminars and laboratory classes, there is training in an online format using gamification approaches [14], as well as their combination i.e. blended learning.

Blended learning and other types of modern education, such as the concept of lifelong learning, require effective infrastructure support. This means the use of cloud technologies with microservice architecture and load balancing and distribution, web applications and robotics solutions together with artificial intelligence to improve functionality, increase efficiency and obtain qualitatively new opportunities.

A new type of learning described for the first time in [1] is Triple Learning, as a combination of three separate parts.

1. Traditional education including lectures, individual, practical and laboratory work
2. Independent, mostly online study of selected MOOCs offered by the teacher in accordance with the course topic
3. Team or individual work on creating one's own project with public defences during and at the end of the course

It should be noted that the Tripled Learning does not depend on the physical presence of students in the classroom and can be conducted both online and offline or in a mixed form.

Since the first publication [1], the Tripled Learning format has been successfully tested and expanded to work with telepresence robots. According to the proposed triple training concept, training performance has improved significantly, although direct comparisons are currently difficult due to the specifics of the pandemic restrictions and the current state of war.

We can say that triple education is successfully integrated into the reality of the educational process at the University.

4.2. Mixed Learning and Modular e-Learning Systems

In the learning process of a mixed approach to education, one can use various electronic learning systems, mainly the learning management system (LMS). It should be noted that a special class of LMS, namely intelligent educational systems (ILMS), can be created both on the basis of existing e-learning systems and in a new format of personalized smart e-learning. For example, the article [15] describes ILMS built using Moodle; another example can be a system based on the popular open source LMS Open edX [16].

A typical intelligent educational system for e-learning has separate components, namely a teacher module, a student module, a knowledge module, as well as an interface related to them, mainly in the form of a web application.

As part of the teacher's module, certain important parts should be distinguished, such as diagnostic blocks, subsystems of competence, including a part for examination review and various modules with questions, tests, etc.

In the student module, a separate subsystem monitors the current level of the student's condition. Moreover, due to the built-in artificial intelligence, it becomes possible to conduct personalized training with an individual learning roadmap. Thus, it is possible to adapt the educational process in accordance with individual characteristics and the success of mastering the educational material.

The next very important part is the knowledge module, which contains learning objects as part of the learning content, as well as test questions for exams, a competency measurement system, and other necessary components.

The overall management of the system takes place due to a web-oriented user interface that allows students and tutors to display educational content, configure and adapt it according to a personal training plan (roadmap), as well as additional features available to support staff, managers and administrators.

The blended learning format with the use of telepresence robots allows monitoring of exam performance and academic integrity. The high quality of assessment can be ensured by additional questions from the expanded test database.

Blended learning received a new lease of life due to the forced limitations of the pandemic and showed the prospects of effective learning precisely in its mixed format, when part of the students are present in the classroom, while others study remotely thanks to telepresence robots. At the same time, the quality of education does not decrease.

In the proposed approach, in addition to telepresence robots, there are also other types of robots such as manipulator robots and transport robots. All of them work synchronously and interact in a common learning environment with software built on the ROS, and thanks to the support of multi-interaction, they do not interfere with each other.

This allows you to conduct effective blended learning and adapt to different subject areas, both, for example, in the field of information technology and, in this case, in the field of training future doctors.

Due to manipulator robots that are controlled remotely, it is possible to conduct various types of laboratory work with models of biological objects or educational medical simulations in accordance with the specifics of the educational process. At the same time, the safety of staff and students is ensured.

Autonomous telepresence robots allow students from remote locations to approach the object of research, turn the camera in different directions and move around the lecture theatre within permissible limits without interfering with other participants of the educational process.

It should be noted that the perspective of virtual and augmented reality technologies for remote presence, robot control and more complete immersion in the educational process proves to be quite beneficial.

4.3. Robots in Cooperation

Due to the use of the Robot Operating System (ROS) and a special framework for control and interaction within a fleet of robots, it became possible to simultaneously use multiple personalized telepresence robots, each being connected to a student at a remote location, and not interfering with each other. Moreover, other robotic platforms such as robots with manipulators or mobile platforms are also involved in the educational process if necessary.

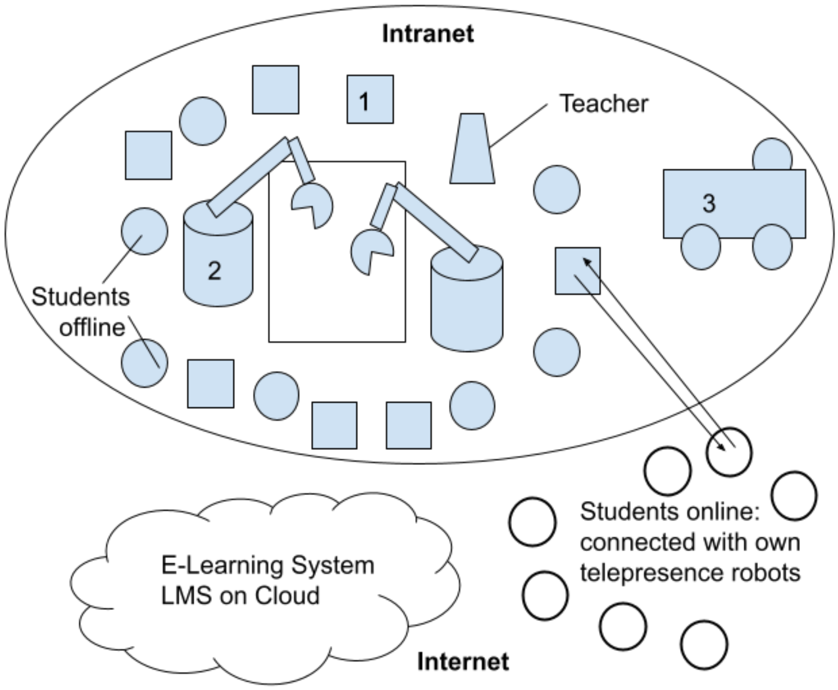

Figure 1: Overall architecture of the MEdOps

Figure 1 shows the general architecture with the corresponding symbols:

1 - personal telepresence robots with two-way connection, each to its remote student,

2 - a robot with manipulators and computer vision and the possibility of autonomous operation under the control of ROS or direct or remote control,

3 - transport robotic platform for transportation of various types of cargo and assistance in the educational process.

The peculiarity of the proposed approach is the use of ROS as the main software platform for the various robotics presented in Fig. 1. Due to this and a special framework for the interaction of many robots, the simultaneous functioning of various robots and the performance of their respective tasks is possible. At the same time, both partial independence in behaviour and human control via a remote user interface are possible. An example of independent behaviour i.e. a transport robot in real time builds a map of the place where it is located and can bypass obstacles that suddenly appear on its path even with the corresponding command of the operator, in case an appropriate message is sent. Another example is when a robot tries to pick up an object, it first checks for its presence and then uses computer vision to detect the exact location to reduce or completely eliminate collisions or mechanical damage. The same applies to the telepresence robot, which has a certain independence when moving and takes into account the location of surrounding objects and other robots. Thanks to ROS and a specialized framework for the interaction of many robots, the possibility of their collisions or obstacles in cooperation is minimized.

It is worth mentioning that the approach proposed can also be successfully applied in the context of gamification. The latter being the strategic motivation factor aimed at engaging participants by incorporating game principles for creating game playing experiences in non-game contexts, in our case learning process activities, enhances functionality and usability of tools and supports interaction among team-members. A detailed concept implemented for team-oriented work by utilizing collaborative effects of gamification from a practical perspective results in improved "overall team-productivity within collaborative, communicative and cooperating environments" [14].

5. Results

The proposed MEdOps approach makes it possible to predictably improve the quality of existing learning process and to build new educational systems [6] without stopping for reinstallations, upgrading, etc. The modular approach allows to adapt the system to the specific needs of the educational process and to update it in a similar way to the standards for the IT industry.

The current version of the described educational approach has been successfully implemented in a number of university-level educational courses, in particular the courses "Basics of Robotics", "Cloud Technologies", "Web Development and Web Design". Due to the versatility of the proposed solutions, they can be extended to the field of medical education [7] as MEdOps.

6. Conclusion and Future Directions

In this paper, we proposed modern approach to integrity of medical sciences with information technologies i.e. MEdOps as synergy of Medical Education with nowadays technologies from education of computer sciences and specially as DevOps i.e. "a set of practices intended to reduce the time between committing a change to a system and the change being placed into normal production, while ensuring high quality" [8].

The one of accents is on implementation of robotics with remote presence or telepresence. As a future direction, we want to improve the MEdOps approach by considering a set of telepresence robots working in cooperation. We are also working on microservices Cloud-based architecture for better functionality of the system.

It can be predicted that the future direction of LMS development will be the following:

1. Integration of artificial intelligence with LMS to create highly effective smart LMS with the possibility of a personal approach to each student
2. Wide use of telepresence robots, humanoid and highly mobile intelligent robots in close cooperation with people and cooperation among themselves

3. Improving the user interface thanks to virtual and augmented reality and blurring the line between the student's physical presence in the classroom and remote presence.

The authors plan to develop this and similar functionality for new versions of educational systems with the full involvement of various robots and virtual reality technologies.

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