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Using Robots in Medical Informatics Education

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Abstract. Although robots have been used for quite some time in education on school and university level, we found no reports of robots being used in the teaching of medical informatics. Thus we present the timetable and structure of a one week, 2 ECTS blocked course for robots in medical informatics initiated in autumn 2022. 19 participants completed the first iteration. We report about the requirements in terms of an appropriate programming environment, the combination among robots and our medical informatics lab and the results of the student's evaluation of the first instance as well as the experiences with the two types of robots used.

Keywords. Robots in medical informatics, teaching

1. Introduction

Robots have been used for some time in education, often starting at school level and commercial products such as NAO are available [1,2,3]. In a scoping Medline search no reports of robots used in the medical or medical informatics education have been found, although the use of robots in medicine has been reported e.g. for surgery [4], neuro-rehabilitation [5], cerebral palsy [6], and as learning systems for improved health literacy [7]. In the ongoing SARS-CoV-2 pandemic, Cruzr robots have been used as a first line to detect the body temperature of visitors or patients and interact with them in multiple languages [8, 9].

Bern University of Applied Sciences (BFH) offers a BSc in Medical Informatics since 2011 [10]. The three-year program comprises 180 ECTS and has recently advanced to a new study plan. Furthermore, the faculty and institute of medical informatics provide a medical informatics lab comprising nearly all institutions of the Swiss healthcare system such as inpatient care including surgical theatre and intensive care, GP practice, pharmacy and an AAL environment for research and teaching purposes. A novel hands-on course using robots has been introduced into the Medical Informatics study.

2. Methods

The so-called block-week is a new format valued 2 ECTS within the remodeled BSc study. Students will complete three block-weeks at different levels. The goals for the block-weeks are

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- To perform interdisciplinary projects
- To select adequate methods from the different subject areas for realization
- To organize teamwork

From 15th to 19th Nov 2021 the second year students (n=19) had for the first time a block-week "robots in medicine". Two Cruzr [11] Version 03H18001/3.7.6 and two Pepper [12] version 1.8a with Python API on NAOqui 2.5 have been provided for four student groups with a group size four to five. Three instructors supported the course. Fig 1 is taken in the course.

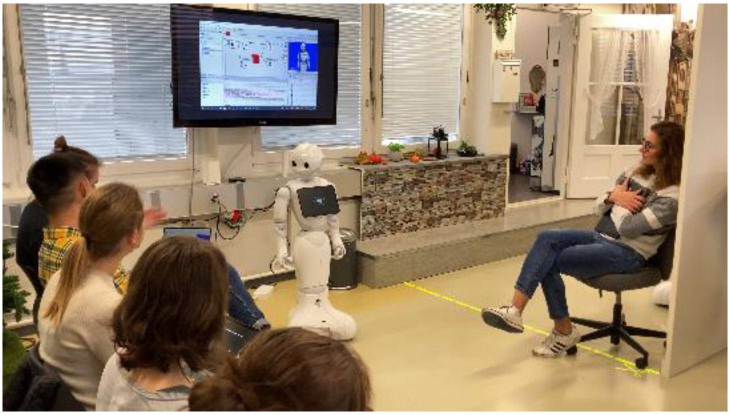

Figure 1. A group of students in introduction to visual Pepper programming interface

The following assignment was given in 2022: "Establish a medicine-related guided visitor tour in the BFH medical informatics lab". A competition was announced for the best lab tour to win a prize. The task was split in daily subtasks. Monday, the student groups should be able to move the robot in the lab and let it tell first sentences. Tuesday they should be able to move each joint of the robot, to let the robot navigate throughout the lab and to make it touch a mechanical door switch. Wednesday was dedicated to basic speech recognition, so that the robot would interact with the user. Thursday was reserved for freestyle programming. Friday morning was a joint activity of block-week #2 (robots) and block-week #3, who had performed a tour de Suisse to various hospitals and Medical informatics suppliers, and comprised the competition for the best lab tour with a timeslot of 15 minutes for each group.

Each day, accompanying plenaries were organized with external speakers, e.g. a) how does the Swiss company raumcode employ robots, b) which Swiss pharmacy data resources and services are available, c) how could the Laerdal patient simulator interact with the robot. The course timetable is provided in fig 2.

A generic control interface over websockets named RobotControlAPI was implemented by RG to enable the students for "detached" layered programming of the Cruzr robots. A client implementation for Python was developed as well for the students to use. With this client the students could develop code in Python which triggers functions of the Ubtech Cruzr. The Ubtech Cruzr is split into two parts, a tablet with Android 5.0 for the user interface on which the websocket interface was programmed and a ROS deployment on Ubuntu 18.04 for the motor functions and navigation. Program

Code of all groups was collected in GIT. For the Pepper robots the Choregraph 2.5.10 programming interface was recommended, but Python 2.7 SDK was enabled as well.

	Monday 15th	Tuesday 16th	Wednesday 17th	Thursday 18th	Friday 19th
08.30-10.00	Intro Demonstrate Cruzr labtour group-building plan for the week	presentation Mr. Stauffer, raumcode	presentation Mr. Sonnenschein HCI	presentation Laerdal patient simulator	presentations of block-week #3 visits in hospitals and companies
10.30-12.00	presentation: How to navigate robot	presentation: How to move arm and hand	presentation: language recognition	presentation advanced NLP	competition 4 groups block-weel #2
break					
13.00-17.00	free programming goal: robot talks and moves around	free programming goal: robot opens door and can navigate complete lab, tells story for every station	free programming goal: robot recognizes drug and tells at least dosage and use, communicates with HUE	free programming frestyle competition	prepare final documents and finalize work

Figure 2. Timetable of the block-week #2 in 2022.

3. Results

The final results of block-week #2 and #3 were demonstrated Friday morning. Due to lab space restrictions and COVID restrictions, remote transmission of Video to a large classroom was organized. The best guided lab tour was voted from all students of both block-weeks and a prize was distributed to the members of the successful groups. Two groups using the Cruzr robot presented the full and comprehensive lab tour including individual add-ons. The winning group could show the potential of robot remote activity avoiding the risk of infections. They made their Cruzr ask the tour participants for a valid COVID certificate and check it out before the lab tour started. If the certificate was nonexistent or invalid, the robot would instruct the visitor how to get a COVID test nearby. One Pepper group demonstrated the "Face-tracker" mechanism of the Pepper which follows a person through the lab.

The BFH courses are evaluated on a regular basis with standardized questionnaires. For block-week #2 the evaluation had a good response (13 from 19 = 68%), some of the results are given in table 1.

Table 1. partial evaluation results of the block-week #2, 13 participants, mean values, range 1-4

	Mean on 4 pt Likert scale
I could work independently	1.5
I achieved the set goals mostly	1.5
The instructors supported with constructive critique	1.5
The instructors were open for questions	1.2
Study goals and assessment criteria were timely known	1.8
External presentations delivered new input	2.1
Overall impression of the course	1.6

Results are measured on Likert scale between 1 = best and 4 = worst where 2.5 would be the median. The overall evaluation of block-week #2 was best among all three block-week events. Individual feedback comprised comments such as "learned a lot" or "activity in the lab was good" or "good working environment". Some critique came for the Pepper robot hardware and the organization for the two Pepper groups, which could be improved.

4. Discussion

The primary goal of the course was to motivate students to find out how robots could be potentially used in a medical environment. Thus, the competition character, and the winning group demonstrated a nice example mimicking a case where robots might be the first contact of a potential infectious person and perform some kind of triage until the person's status is confirmed. It was known in advance that the available hardware has limitations and may not be optimal for medical use cases. Both robots are unable to manipulate heavy objects with their hands, in part due to the fact, that for security reasons the finger joints do not give resistance. Both robots do not have a tray and are not well suited to carry heavy loads. In the case of Pepper, load bearing is also hindered by the threat of instability.

Activities such as opening doors are not possible due to the safety design and control options of the extremities of both Cruzr and Pepper. It was disappointing however to see, that even the stripped down task of pushing an electric door opener switch could not be accomplished. It was impossible to move the robot repeatedly in exactly the same position by programming methods. This task was therefore skipped and successfully replaced by WLAN based interaction with HUE lamps and switches, e.g. to turn on the monitor of the radiology viewing station the moment the robot stopped there and explained this application.

Furthermore, the two kinds of robots are different by nature. Pepper is more a "social robot" with an emphasis on verbal and optical interaction with a human present in the room, while Cruzr, derived from industrial cleaning robots, is a good navigation robot supplied with LIDAR sensors. Cruzr can be fed with external map data of the environment and is therefore somewhat better suited towards e.g. leading a lab tour over some distance. One of the Pepper groups circumnavigated the weakness of Pepper in long-distance navigation using the "Face tracker" mechanism. Thus, the visitor would stroll himself through the lab and Pepper would follow him and give comments where appropriate. The other Pepper group limited themselves to the pharmacy environment without moving large distances.

For all groups it was easy to let the robot talk predefined sentences, e.g. explaining the different parts of the lab in intermediate stops. A problem was the pitch and language in the Pepper robots and Pepper groups did not change to German as the conversation language. This was partially improved when the speed of talking was adjusted programmatically. All groups were able to program their robots to understand simple sentences based on catalogued phrases and search words. There is room for improved NLP processing in future iterations of the course using either internal or external AI methods for real-time "intelligent" interaction.

Originally it was planned that the robot should take an arbitrary drug package from the table, scan the barcode data, and, based upon a Swiss pharmacy database, tell the user what the drug was good for and how he should take it. Due to the mentioned problems with physical interaction the task was slightly altered. All groups were able to position a drug package in front of the robot's built in camera and to recognize the drug.

5. Conclusion

According to the module description, students of block-week #2 should

- Understand through own experience the connection between knowledge and its practical application
- Understand and use their knowledge in practice related tasks and choose the adequate methods from different subject areas for realization
- Judge and solve problems in shape of a practice oriented task which utilizes learned methods

It seems fair to state that these goals could be achieved. Furthermore, evaluation results suggest that the participants enjoyed the format and the given opportunities for independent group work. They learned that programming a robot is not a miracle and that visible effects can be achieved in a short time span. They (and the instructors) gained practical experience with the limitations of current hardware and should now be able to describe the requirements for "medical grade" robots. They experienced the need for fault tolerance in medical programs, e.g. when the robot stopped completely, just because it could not interpret the coded data of a given drug package.

The restricted physical capabilities of our hardware prompted us to acquire a new robot named Lio [13] which is better suited for physical interaction e.g. with drug packages. It will be interesting to see if we need either a variety of specialized robots for each task or if the dream of an universal robot becomes true which can be used for various activities in a medical environment.

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