DEDICATED APPLICATIONS OF TELEPRESENCE ROBOTS FOR EDUCATION

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Abstract: Some companies have launched telepresence robots with applications in education, management, conferences and workshops. Robots available in commerce are somewhat simple, with just one tablet, a smartphone, or a computer at the user. The robot itself is made up of a robot car, a telescope bar, a display (tablet, smartphone, or dedicated crystal display), software and it makes a realistic remote communication that enable the user to interact effectively with the remote environment.
A challenge in the field of research and design of telepresence robots is the realization of humanoid robots that allow the human user to connect to the robot through wireless technologies and with sensors to take on environmental sensations and interact with the environment where the robot is. Until such robots become available to the general public, several steps should be taken: solving the balance problems and digital control of the current humanoid robots, customizing the public with robotic humanoid applications, studying the interaction between people and telepresence robots and using the data obtained in the design of robots.
In the educational system, telepresence robots can make possible the virtual participation of the students with disabilities, that can't be transported to school, to the class for taking part at the courses. Also, telepresence robots can be used for multimedia educational projects which involves filming and taking photos in dangerous areas for humans such as: caves, small spaces or areas with radiation.
The problem of the commercial telepresence robots, to be used in education, consists in two elements: they have big dimensions, weight (not easy to carry for kids) and are expensive.
In this paper we present three projects as alternatives to commercial telepresence robots. The first two are based on commercial educational kits that are easy to mount, have software installed, but are less flexible for applications dedicated to telepresence robotics. The third project is made with open source components that offer a lot of flexibility at a low price and allows the implementation in the software of the desired mathematical model.
We also have analyzed, in this paper, the interaction of secondary and high school students with the telepresence robots, so we have find some future directions of research like: intelligent autonomy dedicated software, a commercial design and the possibility to be easily personalized for each user or class of students.

Keywords: *telepresence, robot, Arduino, applications, education, television, operator, photography.*

I. INTRODUCTION

Telepresence include technical devices which allow a person to interact with a place, other than the true location, using telerobotics.

Teleoperation means to remotely control a machine from distance. Telerobotics combines telepresence and teleoperation with the goal to control semi-autonomous robots from distance. [1]

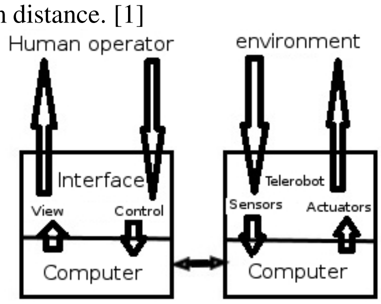

Figure 1. Telepresence robot schematics

Commercial telepresence robots have two main interfaces: one on the user and the other in the environment where the telepresence robot is.

Figure 1 shows the commercial telepresence robots schematics. Both interfaces (one for user and the other for environment) are based on the combination of mechatronic and multimedia elements.

The user interface can be a computer (PC, smart phone or tablet), a software (even a mobile application), or a more complex system of human-body sensors, cameras, speakers and microphones.

The environment interface can have various forms from a tablet or phone with a telescopic robotic monopod with wheels to a complex humanoid robot with head, hands and body.

Our plan was to create three modular telepresence robots, for dedicated applications in education (two mini telepresence robots for classrooms) and multimedia

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professional high school (television operator technician class).

The main difference between the commercial existing robot and ours consist of modularity, flexibility and low cost.

When designing robots, we took into account the need for robots to be easily transported, but also for the robot's need to make decisions alone in a state of autonomy, or when the communication link (wi-fi, bluetooth, mobile internet) with the human operator is interrupted.

II. DEDICATED APPLICATIONS

Three dedicated applications of robotics in the multimedia field are presented in this paper. The first two are based on commercial educational kits that are easy to mount, have software installed, but are less flexible for applications dedicated to telepresence robotics. The third project is made with open source components that offer a lot of flexibility at a low price.

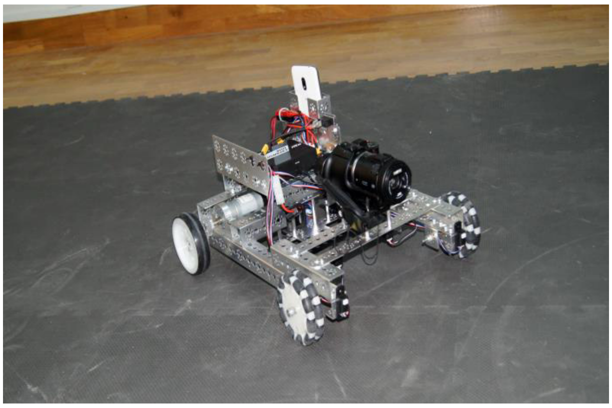

Figure 2. TV operator robot

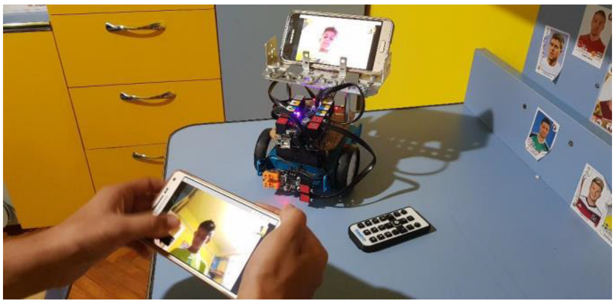

Figure 3. Mini telepresence robot in action

The objective of the dedicated applications presented in this paper is to apply telepresence robotics in education, offering the professionals in these fields the opportunities they want.

Students who need to make documentaries and school projects from caves, small spaces or dangerous zones, will be able to send a telepresence robot like the one form figure 2, equipped with a professional television camera, to transmit, besides the recorded images, and field data, obtained with the help of sensors placed on the robot, such as: temperature, humidity, distance measurements with laser sensors etc.

Educational institutions (schools, universities, etc.) will be able to physically "presence" in the classroom of sick students, who cannot participate to the courses, through telepresence minirobots like in the figure 3.

The first two projects were assembled together with students from Deva Technical ”Dragomir Hurmuzescu” Energy Technical High School.

In order to quantify work and encourage students to have effective work, we participated at local, national and international technical competitions and events, where not only students, but also academics, engineers and multinational companies attended.

2.1 TV operator robot

Making a robot for multimedia communications covers a common problem in the media: risk areas for human operators. The project has two main components: the robot itself (mechanical and electronic components), three mobile phones (one on the robot) to run the software, a joystick and a semi-professional JVC GC-PX100 video camera with an integrated wi-fi communication system.

The project from figure 2 is a robot for multimedia communications and has applications in areas such as: reconnaissance missions in dangerous and war zones, exploring caves or searching for survivors of natural disasters. The robot can also be an autonomous TV operator robot (or CameraRobot, if we can call it that) used in multimedia projects such as live broadcasting via the internet, video-TV broadcasts or live broadcasts of events.

The robot has several components: mechanical (chassis, gears, resistors, supports), electric (power supply, motors, connecting wires), expansion hub, computer and software. On the chassis (made with elements from Tetrix Robotics) are two AndyMark engines, a REV expansion hub (hardware) and a mobile phone (Motorola G4 Play for software running and wi-fi). For the remoted control of the robot we used a mobile station made up of another mobile phone and a Logitech F310 joystick.

The software element is based on the Java programming language and is loaded into the mobile phone used in the project. The program will make it possible for the robot to make decisions during the period of autonomy, but also communication with the human operator. The telephone on the mobile control station is attached, via a usb cable, to a joy-stick console.

The multimedia component of the project is the JVC GC-PX100 video camera, which offers a progressive recording of 1080 / 50p, each frame being a full high resolution image, which makes it possible to capture clear shots from recorded movies. The camera also has a built-in wi-fi system that makes it possible to remotely control the camera and view the image captured on a mobile phone with an application.

2.2 Mini telepresence robot made from a commercial educational kit

The project shown in figure 4 has two main physical components: the robot itself (mechanical and electronic components), a mechanical adaptor for the phone and a mobile phone located on the robot to make a video connection using application like Skype or Messenger.

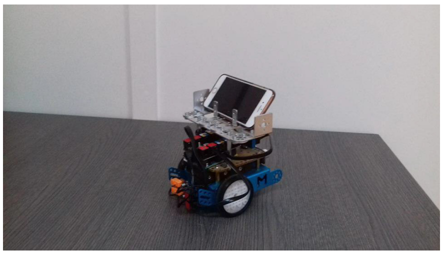

Figure 4. Mini telepresence robot

The robot is built on a mBot kit provided by MakeBlock and is easily assembled due to its modular structure.

The development environment is based on Scratch and can be downloaded from the manufacturer's site (works on Windows or Mac).

The application allows control of the robot running on the mobile phone and can be downloaded by on the manufacturer's website.

We can say that mBot is the easiest educational robot for schools in order to achieve practical programming experiences, Arduino open source projects and robotics. It is an all-in-one solution for robotics learning with the possibility of remote control via wi-fi and Bluetooth technologies. [4]

The telepresence mini-robot is equipped with a smartphone that runs a video conferencing application (Skype or Messenger) and will be connected to the internet.

2.3 Mini telepresence robot made with open source and freeware components and tools

The third project (shown in figure 5) uses, for the robotic part, open source and freeware components and software: Arduino Nano developing board and shield, motor driver for Arduino, Arduino IDE software development environment and the MIT online development environment for android applications.

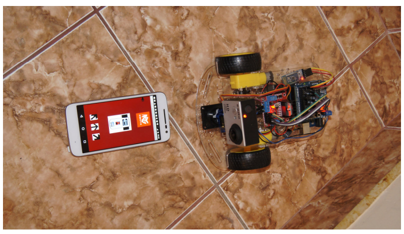

Figure 5. Mini telepresence robot with open source parts

The robot itself is easily assembled with open source components (Figure 6), and the variant built within this project does not need the ultrasonic sensor, but a further development can be developed in which the robot can avoid obstacles in the state of autonomy. [8]

Figure 6. The components of the robot chasis

The mini telepresence robot includes, besides the robotic component, smart mobile phones, integrated wi-fi video camera and a mobile application for controlling the robot's movements.[8]

The mobile application code was made using the MIT platform with block coding. The code is easy to be understood even by persons without initiation in programming, as shown in figure 7. [8]

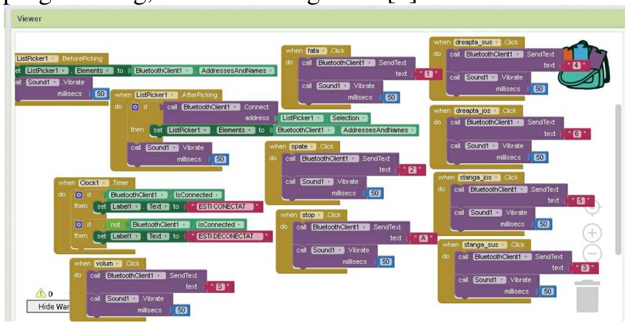

Figure 7. The mobile app block coding [8]

The application flowchart diagram is shown in figure 8. It gives characters to the Bluetooth module, at every application button pressing: ”4” for left button, ”2” for forward button, ”4” for left button, ”6” for right button and ”5” for stop button.

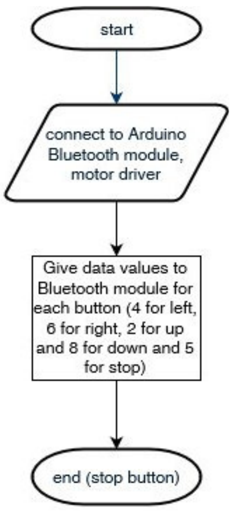

Figure 8. The mobile app flowchart diagram

The Arduino code flowchart diagram is shown in figure 9. After starting, it initializes pins, sets transmission speed at 9600 and set pin mode output. After this step, in a void loop, it reads serial dates from Bluetooth (RX/RTX) and make the actions. [8]

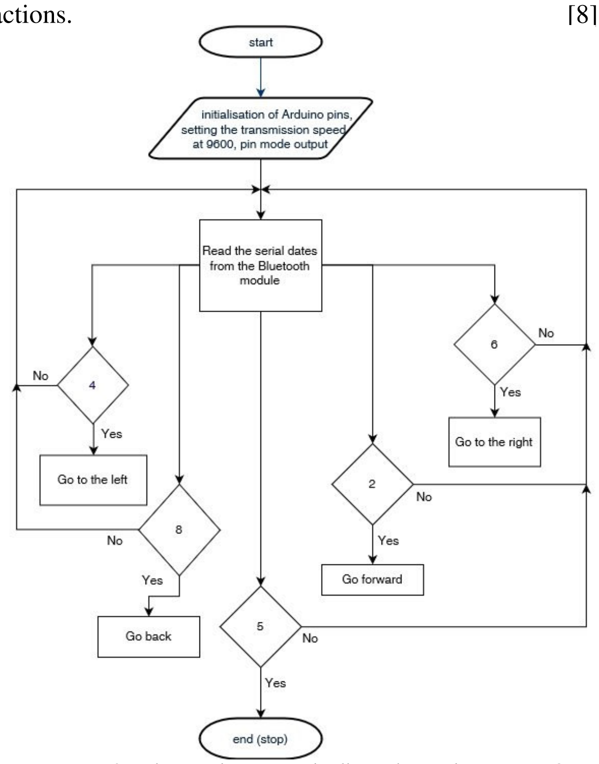

Figure 9. The Arduino code flowchart diagram [8]

For including in the programming algorithm the possibility for the robot to go in an indicated direction with an angle, we need the mathematical model of the robot movements.

If we get a reference point A on the vicinity of the robot, we can note r as the radius of the circular movement of the robot, turning to the left and we can consider all the velocities in the xOy axis system, like in figure 10.

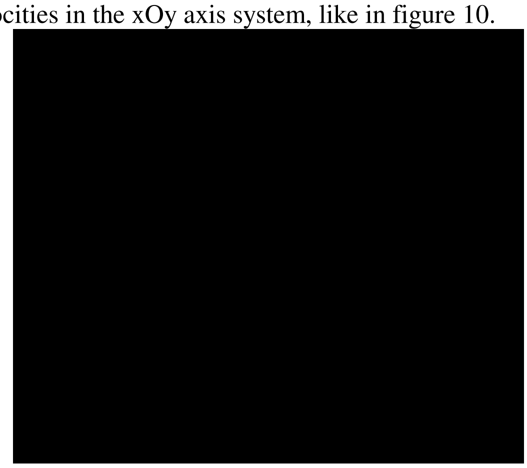

Figure 10. The robot velocities when turns to the left

The equations (1), (2) an (3) show the velocity, decomposed on each coordinate axis and the angular velocity according to the curve angle the robot will describe and the speed of each wheel:

$$\mathbf{v_x} = \mathbf{v_r} cos \propto = \frac{\mathbf{v_s} + \mathbf{v_d}}{2} \cos\propto \quad (1)$$

$$\mathbf{v_y} = \mathbf{v_r} sin \propto = \frac{\mathbf{v_s} + \mathbf{v_d}}{2} \sin\propto \quad (2)$$

$$\omega = \frac{\mathbf{v_d} - \mathbf{v_s}}{d} \quad (3)$$

where $\mathbf{v_r}$ is the entire robot velocity, $\mathbf{v_s}$ is the velocity of the left wheel, $\mathbf{v_d}$ is the velocity of the right wheel, $\mathbf{v_x}$ is the velocity on the Ox axis, $\mathbf{v_y}$ is the velocity on the Oy axis, α in the angle between the robot direction and the Ox axis and d is the distance between the robot's wheels.

III. EXPERIMENTAL APPLICATIONS AND RESULTS

The TV operator robot has been used to practice the notions of multimedia technologies in the practice of the multimedia classroom from ”Dragomir Hurmuzescu” Energy Technical College of Deva. The utility of the robot was shown in areas here the human operator could not access: small caves and dangerous zones.

We also analyzed the level of interest of students in robotics, as well as interaction between students and various robotic applications.

The seven students who have completed the project have undergone online programming, electronics and design courses and have expressed an interest in getting involved in future projects in the field of telepresence robotics.

In the case of the telepresence mini robot, the initial team consisted of three gymnasium students, but after the first working session, there remained only one student who did the project using an mBot kit on modular elements for education in the field of robotics.

Using this robot, experimental math and technology courses were carried out in school class, with sick pupils, immobilized at home, who remotely participated at the courses.

The robot based on the mBot kit has been tested for remote-controlled behavior with the remote. Reactions are fast, without delays and errors.

The robot with open source components was tested for the ability to avoid multiple obstacles and exit a labyrinth, and the results were acceptable. This robot has a high potential for later applicability because the programming environment is permissive and allows for more complex applications than for block programming.

IV. CONCLUSIONS

We intend to focus our attention in future research on telepresence robotics useful in areas such as education, health and sports, and the study of human-robot interaction in these areas, and overcoming the limitations of robots used in space missions.

In the field of education, humanoid telepresence robots can help teachers teach courses in schools thousands of miles away in the same way as physically present in class.

Analyzing the interaction of secondary and high school students with the telepresence robots, we have come to the conclusion that the young generation is eager to experiment and implement telepresence robotics. Therefore, among the future directions of research we will include: intelligent autonomy dedicated software, a commercial design and the possibility to be easily personalized for each user or class of students.

REFERENCES

[1] Minsky, Marvin, *Telepresence*, http://web.media.mit.edu/~minsky/papers/Telepresence.html
[2] Corley, Anne-Marie, *The reality of robot surrogates,* https://spectrum.ieee.org/robotics/humanoids/the-reality-of-robot-surrogates
[3] First Tech Challenge official website, www.natieprineducatie.ro
[4] Makeblock product, mBot, official website, https://www.makeblock.com/steam-kits/mbot
[5] Instructables open source robot car model and documentation, https://www.instructables.com/id/Bluetooth-Controlled-Robot-Car-Using-Arduino/
[6]REV Robotics documentation page, www.revrobotics.com/resources
[7] Arduino open source project official website, www.arduino.cc
[8] □o□a, Paul; Vaida Mircea-F, ”Low cost tepresence robotics fo education”, SSET 2019, ISSN: 1842-6085