Interactive Robotics Workshop

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Abstract. The paper presents an idea and short history of Interactive Robotics Workshop that we have been teaching since September 2013 at the Lodz University of Technology and that was conducted at Ostfalia University of Applied Sciences. For now we had three editions of the workshop: two of them as one day events in Lodz, Poland, while the third one was a three day intensive course in Wolfenbuettel, Germany. The objective of the workshop was familiarizing students with an idea of human-centered-robotics through designing, prototyping and testing small mobile robots based on Arduino controller with user interfaces employing Android devices.

Keywords: HRI,Human Centered Robotics, Interactive Robotics

1 Motivation

There are two main reasons why we have created workshop about Interactive Robotics: (1) the field of service robotics is growing rapidly - new knowledge and experience will be valuable for students on each level, both future operators as well as designers of such robots, (2) as a way to introduce students to a range of different technical and design subjects.

Recently, we can observe clear trend of moving robotic technology from constrained, industrial environment to the human environments. This is because robots have a potential of enormously improving lives of people (particularly in case of disabled people), making several tasks easier and safer as well as commercially feasible or even fun to do. Accomplishing this task requires highly interactive robots, so just as revolution of computer in each home was possible by graphical user interfaces, new robotic applications must be preceded by well designed interfaces. This however, requires highly trained robot designers, who think holistically about working with human centered robotics.

Designing service robots is a difficult task, not only because of the range of technical aspects but also because it requires some understanding of psychology, sociology and design. We can observe a few approaches in this matter: some self-motivated students from technical schools can acquire these skills on their own, or focus on technical skills while collaborating with experts of the other sciences, some universities offer interdisciplinary courses for mixed groups of students

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(e.g., robotics and design) [1]. Nevertheless, students of control engineering and robotics need at least basic knowledge of before mentioned subjects to realize what they do not know, to learn vocabulary necessary to understand difficult design problems, and finally to motivate them to further studies.

Our workshop provides introduction to the design of interactive robots where students can see the design process in action, from the concept and research phase to prototyping and testing on small robots. During this very hands-on workshop students gain knowledge and experience on many modern technical tools for interaction design and robot prototyping. They use Arduino based micromouse robots, Processing IDE to program PC and smartphone applications connected with sensors and actuators kit. For some students this is the most interesting part as they can see and test their designs moving.

2 Main methodology

As we are introducing students to a wide range of different subjects,we had to find balance between theoretical knowledge and practical aspects that would also be interesting for students. We have based our workshop on paradigms of Human Centered and Design Based robotics, described below:

2.1 Human Centered

While robots can be used in many different scenarios, the whole workshop is based on human users and their activities. That is, robots are designed and thought of as human partners or human's tools. This is very important as robots designers understand behavior and abilities of their products very well, but end-users may not. But if the robots end-user is in the center of the design process from the beginning, there is a good chance that the ability to communicate and responsiveness, the intuitiveness of interfaces, ergonomy and comfort of use will be the main part of the design rather than add-on.

This way of thinking about robots - as a tool or partner of humans, gives also well constrained context for novice student designers. They have easier time imagining how the robot would, for example, interact with their family or move around their house, instead of imagining a robot on Mars or under the water. Human context provides also an easy way to evaluate robot designs - students can test their robots with their friends and family. This results in robots, that are more realistically designed.

2.2 Design Based

As highlighted in the previous section our students put end-user in the center of their robot design projects. By focusing on user's needs, abilities and knowledge they can ensure that final robot will be in fact useful, checking it through methods and paradigms established in design community. These methods have been particularly well studied by human-computer interaction designers and although

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switching from computers to robots requires thinking in whole new dimensions, basic methods of need-finding, rapid prototyping, visual design and interface evaluation remain the same. In our workshops, we focused on some particular methods, that we found most useful in human-centered robot design, listed below:

- storyboarding. To understand the human-robot interaction task, students have to understand the whole context in which the interaction is happening, and a simple way to sketch such a scenario is to make a storyboard - a comic-like set of drawings describing what the user is doing and how the robot is involved [2][3]. Drawing such scenarios can help to see the whole picture and correctly plan interaction methods that are practical in a scenario described. Storyboards can also be used in communication with team members or consultation with experts, like on example seen in Fig. 1
- using robot mockups and role playing. Developing a mobile and well behaving robot at the very beginning of the process is a difficult task, however, students can easily use cardboard boxes or not-programmed (yet) robots to animate the proposed construction (Fig. 1). By just having physical object to move and pretend, students can understand what exactly they want to accomplish, what difficulties there could be and even start testing their robot mockups with people. On later stage, similarly they can use Wizard of Oz technique when robot is remotely controlled or animated but behaving as if it was autonomous [4].
- prototype cycle. We introduce students to the idea of prototype cycle, where on different design steps they produce prototypes - object that have some functionality of final robot, of increasing fidelity. In making successful interfaces it is important to iterate, that is to make and learn from repeating. We encouraged students to make their prototypes fast, using code snippets, paper models and whatever material they had around them. At the beginning their prototypes can be very simple moving robots (or objects), drawings of interfaces. Each of these prototypes can be used to check whether their design intention is correct. With a very simple model it is much easier to focus on important features instead of technical details.
- evaluation procedures. Robot designers typically spend long time with their constructions and get used to their quirks. To objectively evaluate their designs, students in our workshop had to use evaluation methods used by interaction designers such as Jacob Nielsenn's ten design heuristics [5], design studies with users or design comparisons. This makes final designs better as well as guides on design procedure.

3 Tools

While the whole section above described the workshop's philosophy here we present some tools we found particularly useful in teaching the interactive robotics. These tools must fulfill a number of requirements: have easy learning curve, be

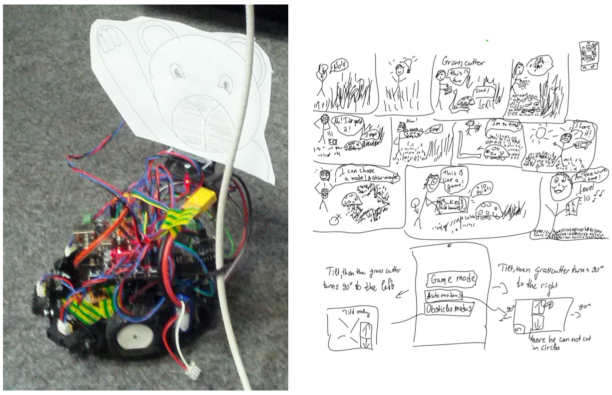

Fig. 1. a) Example of robot mockup. b) Simple storyboard of grass cutting robot game created by students of Interactive Robotics workshop

fast and robust, be usable but in the same time not limiting for those students who would like to explore these subjects deeper. In our workshop we used Arduino devices, the Processing language and modern Android based smartphones and tablets. This set of tools provided best balance between ease of use and flexibility, so that students could start fast but also have ability to use their knowledge in further projects.Taking students out of computers, giving them paper, crayons and making them playing roles also proved to be invaluable.

3.1 Arduino Micromouse robots with a set of tools

Arduino is a great tool for prototyping electronics. To ease introduction to electronics and give students the ability to work on higher level of abstractions they were given ready to use code snippets, API for robot control (PID speed controller, interrupt based encoder, etc).

Base robot for the workshop was a micromouse like robot with encoders on wheels, Arduino clone romeo board with H-bridges and a Bluetooth module, as shown in Fig. 2.

Each of student group was provided with such a robot and also a set of additional sensors and actuators like light sensors, tilt sensors, servo motors, diodes, flexion sensors, encapsulated as a building brick to avoid unintentional damage and ease the operation.

3.2 Processing

Processing is a programming language and IDE focusing on interactive applications. Created in the way that non-professional programmers, such as artists, could make their own programs. It gives easy access to non typical methods of interaction - sound, gestures, sensors. As interaction with robots usually happens while the user is away from the computer, therefore, easy access to a wide range of interaction methods is essential.

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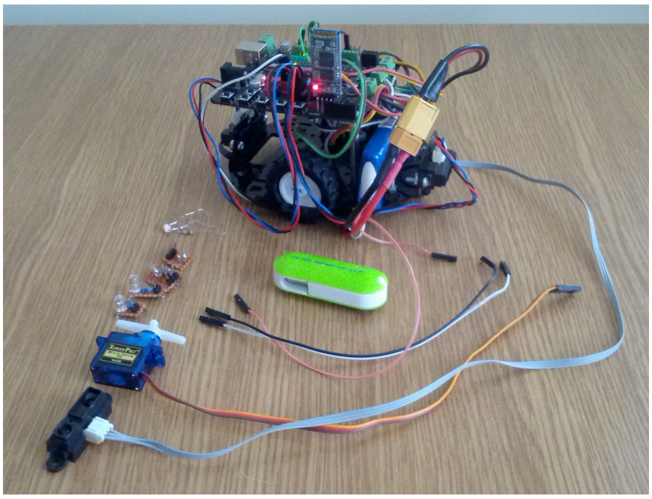

Fig. 2. Arduino micromouse robot with bluetooth, diodes, servo, tilt and range sensors.

We have prepared a set of example programs explaining the Processing functionality in context of robotics. Some demo procedures included: visual presentation of the state of the robot, moving the robot by the PC mouse with Bluetooth communication, or the sound generation.

Processing has also a dedicated mode for Android system as well as a set of libraries providing access to most of Android devices' features [6][7]. Most prominent of them - Ketai library was used in most of examples provided for students as it gives a very easy - (usually only couple lines of code) access to most of smartphones features: sensors (gyroscope, accelerometer), touch screen, gestural interface, camera, vibration, etc. (Example of students' applications can be seen in Fig. 3). Ability to make applications that could be given to end users for tests, without having them come to computer, made students focus on the interaction and not on the development process itself, as they could see how applications are used in natural environment.

Processing is JAVA based (although much simpler), all libraries for this very popular language are available. Ease of use of Processing allows rapid prototyping of Android applications and JAVA origin makes this applications easily expandable. Therefore, programs developed during the workshop are not wasted at any point, can be shared, and can be a basis for a fully developed, mature programs.

3.3 Analog prototyping

One of the main design methods is the use of abstraction - although the result of design is a physical artefact - interactive robot - the whole design process is based on its representations: plans, prototypes or word descriptions.

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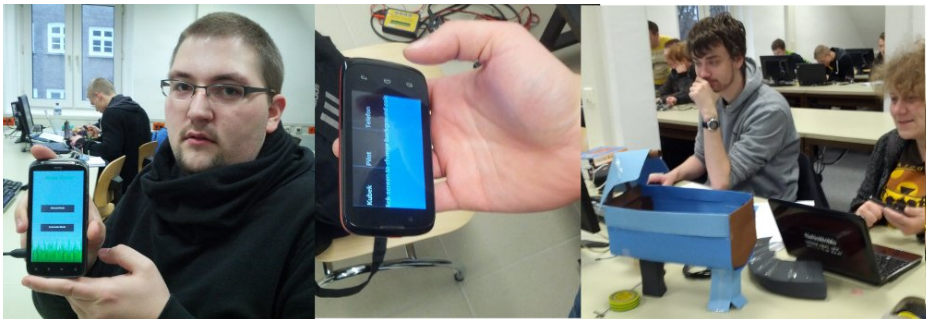

Fig. 3. Students prototypes a),b) Android applications for robot control, c) Robo-Nanny

In such demanding projects like interactive robots, working only on the technical aspects can be very misleading and narrowing the picture (one see a tree without seeing a forest). Therefore, design tools must help to understand the main problem, divide and share the work, prioritize it, and evaluate. Analog prototyping - talking, using paper, role-playing - provides very high level of abstraction, robot's functionality is imagined and as so, can be very easily modified.

Paper prototypes are also very good for receiving and delivering critique. Firstly, because little work was needed to create them, the designer is less likely to defend them without strong cause. Secondly, the person asked for an opinion knows that not fully developed product and she or he can be stronger in judgement. Paper prototypes can also be cheaply and quickly modified so the iteration process can be really rapid [3].

Role-playing and describing the robot-under-design forces team-mates to step aside the computer (the keyboard) and allows natural interaction between them. In contrast groups working only on the technical subjects students may just tap the keyboard without talking to each other and this could lead to very uneven projects.

4 Workshop history and results

Interactive robotics workshop was conducted three times in evolving form. The first edition was prepared for the Robotix Week in Lodz on 17th September 2013 as a part of Visegrad Robotics Workshop project [8]. We had very diverse group of participants starting from the high school students, through IT and robotics undergraduate, graduate and PhD students, up to faculty members from four countries: Belarus, Czech Republic, Slovakia and Poland.

Second edition of the workshop was conducted with a group of young students from the Robotics Research Association. Some of them had previous experience in robotic contests (e.g., line follower, sumo robots) but they had no experience with design methods and the interactivity.

The third time was the longest and the most intense, conducted as a set of lectures and workshops at Ostfalia University of Applied Sciences, Computer Science Faculty as a part of International Week between 25 and 27 November 2013. As a longer (24 hours long) course there was a longer time designated for a theory of interactivity and best practices.

Introductory workshop was divided into two parts, one focused on design skills necessary to build interactive robots: observation and user needfinding, paper prototyping, storyboarding and storytelling and design evaluation as well as the second part teaching technical skills such as: robot control, usage of different sensors, Android programming.

Basics were introduced by the series of exercises, where lecturer was explaining example code followed by demonstrations made by students who presented and tested their robotic ideas.

Main part of the workshop was focused on some particular human activity that could be robotized or improved by the use of robots. It had to be quite simple idea that could be done and tested in place, therefore, students limited themselves to students' or home life. Their task was to design and test the first iteration of the idea. Students could modify examples to create interfaces that used Bluetooth, accelerometers, touch interfaces and other tools available. Their challenge was to design an interface that would be straightforward enough for members of other teams to use without long explanation. Example of such project is described in case study below.

4.1 Case study: developing friendly grass cutter robot

The Grass Cutter robot idea and prototype was developed by three students from Ostfalia University: Tina Heiliy, Lars Kelm and Oliver Bouffcher.

Students first started with brainstorming different ideas, focusing on a scenario of any service robot that could be used around home. Four of the best ideas were then converted into paper drafts, detailing stories involving using a robot: fetching robot for disabled person, pet feeding robot, grass cutter and hair washing robot. Basing on their rough drawings, students discussed each proposal, focusing on the question: how much a robot could improve each activity. They decided then to develop further the grass cutter robot idea.

Students made a list of features that users wanted to have from a device, such as safety of use, ease of use, making activity more attractive and so. Further they came with an idea of gamified robot grass cutter that would cut grass as a form of a game for the user, their storyboard is presented in Fig. 1.

Students used several paper prototypes for smartphone interfaces and the wizard-of-oz technique for the whole robot activity to evaluate their ideas. When satisfied with design they proceeded to make physical prototypes using Arduino robots and Processing language.

Students decided to use a resistive light sensor for prototype automated mode, tilt sensor to detect someone picking up and turning robot (robot should switch off). Prototype Android interface would show simple buttons for mode

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choice (Game mode, Auto mode, Obstacle mode) and allow to control robot by tilting smartphone as a prototype game.

Students then divided their activity, working simultaneously on robot and Android prototypes. Workshop finished with them presenting paper and physical prototypes and discussing with peers - using Nielsen ten Heuristics as a basis [5]. They did not succeed in producing all they wanted in their prototypes but created and presented a coherent, creative vision of robot that could be easily developed further.

5 Conclusion and future steps

We have presented methodology and the history of Interactive Robotics Workshop that focus on the practical design skills of human centered robots.

Workshops' formula can be used as an introduction to robotics, as human application is easy understood and motivating and as an introduction to human robotics interaction for advanced students of robotics. Currently workshop is given to a group of high school students as a part of project of designing simple robots for autistics children therapy.

In the future we plan to make a spanned version of the workshop that would be more project based and also prepare a manual for the techniques used for a reference.

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