The Use of Social Robot Ono in Robot Assisted Therapy

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1 Introduction

Ono is a low cost DIY reproducible social robot designed to make large scale human-robot interaction (HRI) studies more feasible financially, as well as to make social robotics accessible to hobbyist experimenters. While many HRI platforms exist, most are not suitable for the aforementioned scenarios because they are either too expensive or too hard to modify. Examples of existing platforms are Kobian [1], HRP-4C [2], WE-4RII [3], iCub [4], Kismet [5], Probo [6], Nao [7]. Low-cost options also exist, such as My Keepon [8] and Kaspar [9]. In our opinion, many existing platforms are hard to modify because hardware/software source files are not made available or because the platform relies on high-end components and manufacturing techniques. Our social robot, named Ono was developed with the following goals in mind to address these issues:

Open source.
The aim for Ono is to distribute both open hardware and open software. By allowing unrestricted access to hardware and software, other researchers have the opportunity to easily extend the capabilities of the robot, enabling them to adapt the robot to their specific needs. The source files of the robot can be found in a public Github repository [10], however full assembly instructions are not available yet.

Do-It-Yourself.
Our goal is that Ono can be built without the aid of paid experts or professionals.

Modular.
By dividing the robot into smaller functional subunits, repairs can be made quicker and more easily, modules can be reused in other projects and more specialized can be developed, allowing for a degree of customizability.

Reproducible.
Ono is constructed from standardized components and readily available materials. Custom components can be produced using low volume manufacturing techniques, most notably laser cutting. With this approach, we aim to make it possible to replicate

this robot anywhere in the world, without the need for high-end components or manufacturing machines.

Social Expressiveness.

Ono's face contains 13 degrees of freedom (DOF), allowing the robot to gaze and to express facial expressions. The DOFs are based on the Action Units (AU) defined by the Facial Action Coding System (FACS) [11] as well as our experiences with the Probo social robot [6]. A mapping algorithm translates a valence and arousal parameter to a set of positions for all DOFs using Russel's circumplex model of affect [12], allowing for a smooth transition between emotions.

The goal of this paper is to provide a brief overview of the construction of Ono, as well as to present the results of our first study with children.

2 Construction

Fig. 1. Child interacting with Ono.

Ono was developed as a social robot for children; this had several consequences for the design of the robot. The entire robot is covered in a soft foam and textile skin to attain a soft and inviting appearance for the children, as well as to protect the internal components from damage. The robot has a disproportionally large head to make its facial expressions more noticeable and is posed in a sitting position to improve stability. The main components of the robot are:

Skeletal frame.

The frame of the robot consists of a series of interlocking cross-sections that together form a sturdy structure onto which modules can be attached.

Modules.

Sets of related sensors and/or actuators are grouped into modules. The current prototype has 3 types of modules: 2 eye modules, 2 eyebrow modules and 1 mouth module. Modules are attached to the main frame using snap connectors, making it easy to replace them.

Foam and skin covering.

The outer layers of Ono consist of a polyurethane foam shell covered with stretchable textile. The foam shell is made from multiple pieces that were cut from a flat sheet of foam and were subsequently sewn together over the frame.

Electronics and interface.

The robot is currently controlled from a separate control box with joystick interface. The control box also contains the robot's power supply. Power and data are sent to the robot using the same cable.

3 Pilot study

A pilot study to evaluate the use of Ono in Robot-Assisted Therapy (RAT) was performed in Romania. The robot was tested with 5 children with autism spectrum disorder (ASD), aged 3 to 10 years old. Children were asked to identify the emotion expressed by the robot, they were then asked to mimic the robot's facial expressions and were finally allowed some time to freely interact with Ono. Table 1 shows the interaction rates during the pilot study. Imitation is measured as the number of times that the child had the same facial expression as Ono. Touching is measured as the number of times the child touches the robot. Verbal initiation is measured as the number of times the child talks to the robot. Table 2 shows the recognition rates of happiness, anger, sadness and surprise. The emotions happiness, anger, sadness and surprise were shown in random order, but each emotion was shown 4 times. Because one child did not want to participate in this part of the study, only 16 measurements were obtained for each emotion. The children could easily identify happiness and sadness, anger was often confused with being scared or sad and surprise was often confused with happiness or sadness. During the free play phase of the study, most children continued to show interest in the robot. One child asked to play with Ono after the study ended; he even controlled the robot himself using the joystick interface. Another child played a musical instrument to the robot, and a third child tried to feed Ono. The tests suggest that Ono has an overall inviting appearance that elicits interaction, however some emotions are difficult for the children to identify and should be improved.

Table 1. Interaction rates

	Imitation	Touching	Verbal initiation	Engagement
Child I	11	70	25	3.08s / 4.16s
Child II	0	4	15	2.10s / 3.46s
Child III	0	9	5	2.43s / 9.43s
Child IV	7	13	3	2.09s / 1.29s
Child V	0	0	40	0.23s / 2.55s

Table 2. Emotion recognition rates

	Correct	Incorrect	Don't know
Happiness	15	1	0
Anger	3	10	3
Sadness	15	1	0
Surprise	6	7	3

4 Next steps

Our first results suggest that a low cost social robot can become a valuable tool in RAT and HRI studies. Even though Ono does not possess the same level of capabilities and features as other social robots, we believe there is a place for this type of robots. Low cost social robots such as Ono make it possible to perform large scale experiments, which has not been practical in the past because of the high costs and because often only one prototype of the robot exists.

Our next steps for Ono include fixing the problems discovered during the pilot study, such as eliminating the control box interface, improving the appearance of the facial expressions (anger and surprise in particular) and designing a new, more robust eye module. Additionally, we would like to try new degrees of freedom, such as arm movement and pan and tilt movement of the head. Our goal is to then evaluate different DOF configurations in a large study, to determine the optimal degrees of freedom for applications such as robot-assisted therapy.

We hope that the reproducible design of Ono means social robotics can become accessible to researchers and hobbyists around the world, and that the robot can be used as a therapeutic tool to help children with autism.

5 References

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