Improving the Expressiveness of a Social Robot through Luminous Devices

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ABSTRACT

Social robots during human-robot interaction have to follow certain behavioral norms. To improve the expressiveness of a robot, we focus this work on the visual non-verbal expressive capabilities. Our robot has been equipped with two eyes, two cheeks, a mouth, and a heart (some of them allowing expressive modes non existent in humans). Each one of these parts do the robot expressing different emotions or states, or even communicating in a non-verbal fashion with users.

Keywords

human-robot interaction; expressiveness; social robots;

1. INTRODUCTION

Social robots are devoted to live together with humans sharing common spaces and communicating properly. This means that during human-robot interaction social robots have to follow certain behavioral norms.

In relation to communication, humans exchange information by means of several channels, verbal and non-verbal, to reach a point of understanding. According to Mehrabian [1], most of the communication is non-verbal. Therefore, if we want robots to successfully communicate with humans, we must endow them with such capabilities.

Non-verbal communication is the process of exchanging information without words but using body language (e.g. gestures, postures, or facial expressions), paralanguage (e.g. pitch, volume, or intonation), touch (e.g. caress or hit), or distance [2]. Our purpose is to extend the communication capabilities and expressiveness of social robots with non-verbal channels (some of them do not exist in humans).

In this work we focus on the visual non-verbal expressive capabilities included in the robot *Mini*. This *desktop* social robot is intended to entertain, assist, and watch elders at their homes. The profile of its potential users (people with cognitive problems and/or visual or hearing impairments) makes the expressiveness a key aspect to easy the communication. In order to strength this facet, *Mini* has been equipped with two lively eyes, colored cheeks, lighting mouth, and a beating heart (Figure 1). These elements have been designed to convey the robot's emotional state, its intention, or its excitement, among others.

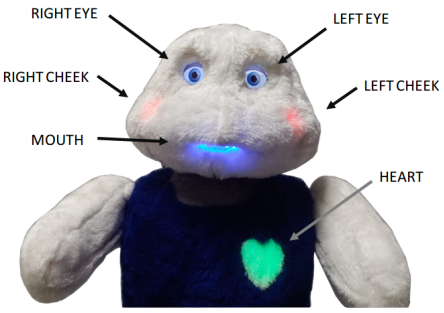

Figure 1: Body configuration of the robot *Mini*.

2. EYES

Humans and other animals can show emotions and mood combining the eyebrows, the eyelids, the pupil of eyes, and movement of the gaze. In the robot *Mini* we try to emulate these natural eyes by means of two screens were two digital eyes are shown. For that purpose, we have drawn inspiration from the design of cartoon animated eyes of several films. The result is that *Mini* can express anger, sadness, surprise or laughter (Figure 2) only with the variation of the curvature of the eyelids and the shape and position of the irises.

The eyes of *Mini* are formed by two screens (Oled LCD 128x128) in an horizontal layout, each one devoted to one eye. The different types of eyes were created as gif files which are loaded in the screens and controlled from external software. Each eye expression consists on a set of three different

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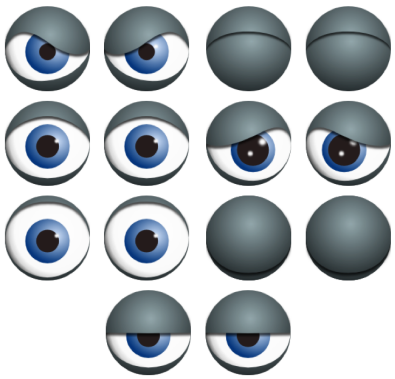

Figure 2: Different eye expressions of *Mini*.

gifs: one for moving the eye from a default position to the open-eye position for that expression, other for blinking with that particular expression, and the third one for transiting from open-eye position to the default position. Considering that the default position is shared by all eye expressions, we achieve smooth transitions when changing the expression of the eyes.

Moreover, the direction of the gaze is very important. For each eye expression, we have nine possibilities: center, up, up-right, up-left, center-right, center-left, down, down-left, and down-right, depending on the position of the pupil. Thanks to these nine possible orientations of the pupils, *Mini* can look in any direction in the room or follow the user with its gaze if it is necessary. Finally, the possibility of modifying also the blinking frequency is very useful, for example, to express more agitation or tranquility.

3. LIGHTING UP BODY PARTS

There are several important parts of the body in a human which can be very useful to show expressiveness. Some of these parts are the cheeks, the lips of a mouth and the heart. Coloring these parts in a robot could be perceived as a body state, liveliness, or an emotion.

3.1 Cheeks

Cheeks improve the expressivity to the robot's face. For instance, *Mini* can blush its cheeks to show shame.

Mini's cheeks are implemented by two RGB leds located approximately on the center of each side of the face. The color of both cheeks can be changed at the same time. All the colors in the RGB space can be displayed, but the red color is maybe the more natural.

3.2 Mouth

In persons, the voice is associated to a movement of the lips. Voice without lip movements is perceived as very unnatural. For that reason, the robot has the mechanism to simulate this behavior by a Volume Unit (VU) meter. When the robot is speaking, the VU-meter uses the output audio signal generated to turn on and off an array of leds placed in the mouth in consonance with the volume. More concretely, leds are switched from center outwards.

The color of the mouth can be changed. By default, it is blue to match with the robot's body color. However, it can be changed to express a particular situation. For example, it can be modified to the red color in order to show annoyance.

3.3 Heart

The heart has been traditionally associated to liveliness and emotional states. For that reason, we emulate a beating heart using colored leds. The hardware of this *artificial* heart is similar to the one used in the cheeks. It consists on a single RGB led controlled by a micro-controller board.

The throbbing of the heart can be fully parameterized: the color, the oscillation frequency, or the oscillation limits can be altered. Considering these features, the robot can show different moods. For instance, a high frequency, reddish throbbing could be associated with nervousness, and a low frequency, bluish throbbing could be identified as calmness.

4. CONCLUSIONS AND FUTURE WORKS

In this paper we have presented different techniques for improving the expressiveness of a social robot, which are implemented on *Mini*, a desktop social robot designed to interact mostly with elders.

As it has been shown, *Mini* has been provided with various colorful leds, situated in its heart, mouth and cheeks. Besides, a pair of screens have been used to implement its eyes. All of these devices permit showing a wide range of expressions, conveying different intentions, emotions, and, in general, endowing the robot with a greater liveliness.

Nevertheless, among all the possibilites offered by these techniques, probably not all of them will be equally useful and/or effective for expressing different emotions or states, or even communicating in a non-verbal fashion with the users. For instance, it could happen that the users do not respond to some colors of the heart because they cannot identify any emotion, perhaps what some people understand as happiness may represent another feeling for others, etc. Besides, a high blinking frequency could make people, specially elders, feel uneasy, but perhaps if it is too slow, it makes the robot not to seem *alive*. Hence, in order to answer these questions and many others, it is necesssary to make an evaluation with real users. That is why in the subsequent months we intend to carry out some experiments in a day care center where *Mini* will interact with several elders, part of who have some degree of cognitive impairment.

5. ACKNOWLEDGMENTS

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6. REFERENCES

[1] Albert Mehrabian. *Silent messages Oxford, England: Wadsworth. (1971). viii 152 pp.* England: Wadsworth, oxford edition, 1971.

[2] S.˜W. Littlejohn and K.˜A. Foss. *Encyclopedia of communication theory.* SAGE Publications, Inc., Thousand Oaks, Calif., 2009.