emoPuppet: Low-Cost Interactive Digital-Physical Puppets with Emotional Expression

Jesús Ibáñez Martínez
Madeira-ITI, University of Madeira
9020-105 Funchal, Madeira, Portugal
jesus.ibanez@m-iti.org

ABSTRACT
In this paper we present a novel kind of interactive digital-physical puppet that includes emotional expression. By adding emotional expression to puppets, we aim to foster reflexion and learning about emotions in kids. Our model consists of both a physical part and a digital one. The physical part is pretty similar to conventional puppets. We minimize the cost of the digital part of the puppets by reusing the smartphones the parents already have. One smartphone, integrated into the physical part, is used for showing the facial expression of the puppet. A second smartphone is used as a remote control for controlling the puppet's emotional expression. Both smartphones are coupled through a Bluetooth connection. Emotions are modelled in terms of the arousal and valence dimensions and they are visually expressed in a simple way through the mouth curvature, the eye opening and the eyebrow shape. By moving the finger across the remote control screen, the puppeteer controls the emotional expression. Both horizontal and vertical axes of the screen are mapped onto the valence and arousal emotional dimensions respectively.

Author Keywords
Puppets; Emotional Expression; Children; Interaction Design; Apps.

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces, Interaction Styles; H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems, Animation.

INTRODUCTION

Nowadays, emotional intelligence is recognized as an essential element for social success and personal happiness. It is now accepted that children should learn to recognize and manage emotions in order to adequately develop their emotional intelligence [1]. However, the development of this competence is not yet clearly and explicitly accounted for by the official educational systems.

We need tools that help the children to reflect on emotions. There exist some computer applications aimed to train to recognize facial expression of emotions in an explicit way. However, we do not know tools that implicitly help them to reflect on emotions by incorporating the facial emotion of expressions in their usual styles of free play.

In this sense, we present emoPuppet, a novel[1] kind of puppet that includes emotional expression. By employing emoPuppet, the kids can invent stories (such as they do with traditional puppets) but they are also responsible for expressing the puppet emotion. By doing so, we think the kids implicitly reflect about emotions: which emotions is the puppet feeling depending on its current circumstances? How should that concrete emotion be shown?

We think that empowering children to express emotions through puppets is pretty natural. Actually, when playing with traditional puppets, children normally integrate the puppets' emotional expression through their voice tone. emoPuppet adds the facial emotional expression.

The proposed emotional puppet can also be handled by parents to create affectively rich interactions with their kids. It can also be used for puppet theater performance.

EMOTIONS

There are two widely accepted coexisting approaches for modelling emotions: the categorical approach and the dimensional approach. The *categorical approach* [2,8] assumes the existence of a set of universal, so-called basic emotions that can clearly be distinguished from one another and form the basis for all other emotions we might experience. There is some controversy on the number of these emotion factors, but as stated by Evans [3], most researchers would include the following six in their list: joy, distress, anger, fear, surprise, and disgust.

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[1] While interesting proposals for digital-physical puppets exist [4], we have not found any for emotional expression in literature.

The *dimensional approach* suggests the existence of major dimensions that are sufficient to describe and distinguish between different emotions. Probably the first dimensional model was that proposed by Wundt in 1896 [10]. Since then, several alternatives have been proposed. Russell's circumplex model [9] is among the most accepted. According to his theory, emotions can be described in terms of two bipolar, continuous and orthogonal dimensions: the dimension of valence with the positive (or pleasure) and negative (or displeasure) poles and the dimension of arousal with the calm and excited poles. Sometimes, an additional dimension of dominance with the strong and weak poles is suggested.

Our model works with the bi-dimensional approach of emotions, where emotions are represented in terms of valence and arousal. In this sense, various authors have described several different emotions using these dimensions by locating the emotion words in the bi-dimensional space. For instance, Figure 1 shows some emotion words according to Russell's circumplex model of affect [9].

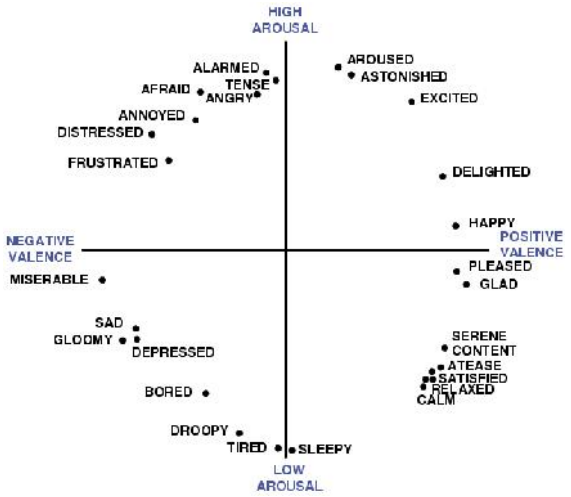

Figure 1. Russell's circumplex model of affect.

The dimensional approach is very appropriate for our case. On the one hand, using the dimensional model simplifies the interaction with the puppet. The puppeteer only has to deal with two dimensions (which also fits the interaction mechanisms with a bi-dimensional smartphone screen very well). On the other hand, the dimensional approach allows a subtler expression of emotions, allowing getting ambiguous expressions.

OUR APPROACH

In the following subsections we describe three important aspects of our proposal. First we explain the emotional model. Then we depict the technology we have designed and developed as well as its general functioning. Finally we show a few examples of physically crafted puppets that illustrate how all the components fit together.

Emotional model

We wanted to define an emotional model that was visually very simple so that it could be easily applied to any kind of character. According to the comic theorist Scott McCloud, the simplest and most iconic character is a face consisting of a circle containing only two points (representing the eyes) and a line (representing the mouth) [7]. Simple and iconic characters have already been proposed to express emotions, but none as simple as McCloud's character. The simplest models we found in literature expresses the emotions through the mouth curvature, the eye opening and the eyebrow shape [5,6].

Valence

Valence, in our model, is expressed through the curvature of the puppet's mouth. More concretely, the mouth is modelled as a quadratic parametric curve segment specified by three points. These points are named p1, p2 and p3 in Figure 2. Two of these points (the horizontal extreme points p1 and p3) are fixed in both the horizontal and vertical axes. The location of the other point, p2, is fixed in the horizontal axis (it is located at the center between the extreme points in the horizontal axis) but it is variable in the vertical axis. In particular, the vertical location of p2 depends on the valence value. The more negative the valence is, the higher the vertical location of p2 is. The more positive the valence, the lower the vertical location of p2 is. As a result, the valence value moving from negative to positive will move the mouth curvature from a downturn U to an upturn U.

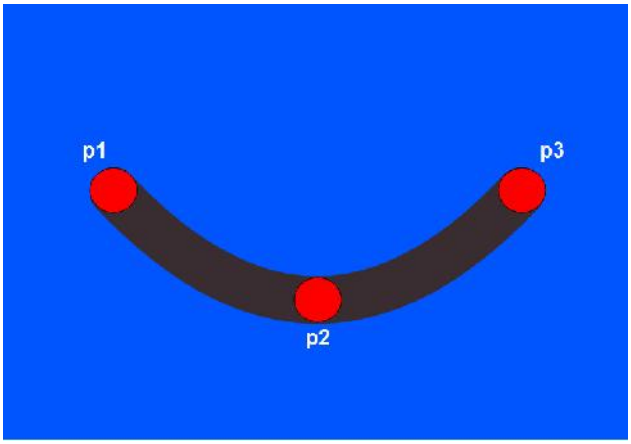

Figure 2. The mouth is modelled as a quadratic parametric curve segment specified by three points.

Arousal

Along the arousal dimension, the size of eye opening grows with increasing arousal and reduces with decreasing arousal. As for the eyebrows, they are influenced by both the arousal and valence values. Under a positive valence, when arousal is low to medium, the outer corners of the eyebrows are raised. The eyebrows become more and more relaxed and straightened with increasing arousal. When arousal is very high, the inner corners of the eyebrows are

raised slightly. On the other hand, the opposite takes place under negative valence.

Technology

In this section we describe the technology we have created in order to support the proposed approach. The technology is an App that works on Android devices and adapts itself to different screen resolutions.

Ideally, the App should be installed on two Android smartphones (although it can be used also with a single smartphone). Both smartphones are coupled through a Bluetooth connection. Both show the same facial expression. By touching any of the phones, the emotional expression is consistently changed in both phones. The puppeteer is free to decide which of the smartphones plays the role of puppet. The other one is used as a remote control for the puppet emotional expression.

By moving the finger across the screen of the remote control smartphone, the puppeteer controls the puppet's emotional expression. Since both phones show the same expression, the remote control provides the puppeteer with continuous visual feedback about the puppet's expression (see Figure 3).

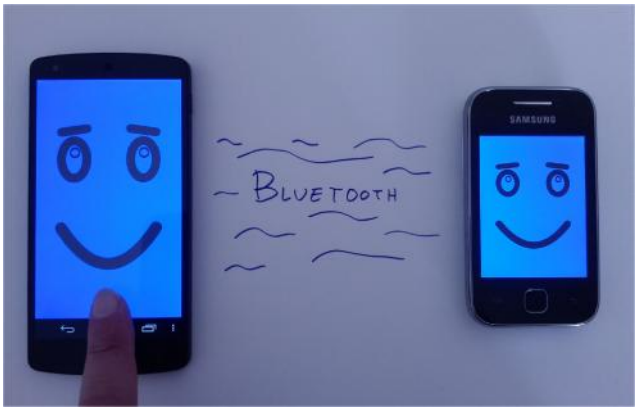

Figure 3. The App working in two coupled smartphones.

Both vertical and horizontal axes of the screen are mapped onto the valence and arousal emotional dimensions respectively. By moving the finger up on the screen, the valence becomes more negative. On the contrary, by moving the finger down on the screen the valence becomes more positive. By moving the finger left on the screen, the arousal becomes lower. In contrast, by moving the finger right on the screen, the arousal becomes higher.

These particular rules for mapping finger movement directions onto emotional values were experimentally determined by testing the interface with a few kids. All of them found these rules as the most appropriate ones. In particular, the interaction regarding valence was especially intuitive for the children. The reason seems to be that the physical interaction in that case is consistent with the obtained visual effect: by moving the finger up or down, the mouth's curvature seems to follow the finger.

Note that, since both phones show the same emotional expression, it is possible to use the technology even with only one smartphone. This is appropriate for toy characters such as shown in the next section.

Physically crafted puppets

In this subsection we show two physically crafted puppets that illustrate two different uses of the presented technology: toy character and hand puppet.

In the first case, the puppet is used as a doll or toy character, with two arms and two legs. We employ a small sock and two pieces of wool yarn. The smart phone is placed inside the sock. As shown in Figure 4, we made a big hole in the sock so that the emotional expression is visible. We also made four small holes to thread the pieces of wool yarn that constitute the puppet's arms and legs.

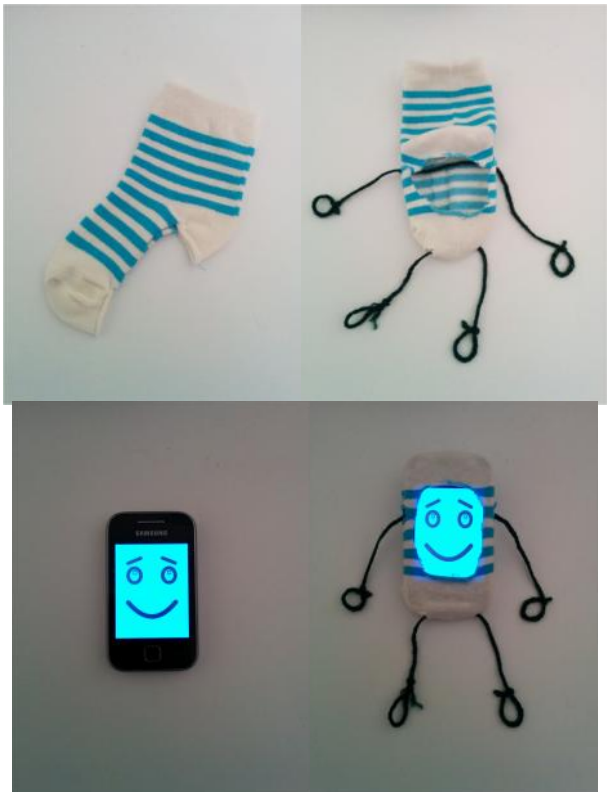

Figure 4. Puppet crafted with a small sock and two pieces of wool yarn.

The resulting puppet can be used by the kids as a toy character (see Figure 5). By touching the face of its characters, the kids change its emotional expression. Thus, the kids can freely play, creating stories where their characters can express their emotions as reactions to other characters behaviour and events. Note that, in this case, the second mobile (remote control) is not necessary, since the kids can change the emotional expression by just touching the puppet face. This is consistent with the way they usually play with toy characters. For instance, they move the hands

or legs of a conventional toy character by directly handling them.

Figure 5. Kid playing with the puppet.

In the second case, the puppet is used as a hand puppet. We sewed two pieces of felt, as shown in Figure 6. Note that the crafted hand puppet has two arms but it does not have a head. Instead, it has a hole so that the smart phone can be appropriately placed as the puppet's head.

Figure 6. Hand puppet crafted with felt and a rubber band.

The smart phone is attached to a few fingers by a rubber band. The puppeteer's hand is then placed inside the felt puppet, while the smart phone remains visible as the puppet head. We add a small sock on top of the smart phone as a puppet hat. Note that thumb and pinkie allow the puppeteer to move the puppet's arms, while the other three fingers allow him to move the puppet's head.

In this case, the second mobile (remote control) is necessary in order to control the puppet's emotional expression in an appropriate way (transparent for the audience). The puppeteer holds this second mobile with the other hand, hidden behind himself.

The resulting hand puppet with emotional expression can be used by parents to create affectively rich interactions with their kids. It can also be used for puppet theater performance.

CONCLUSION

We have presented a novel kind of interactive digital-physical puppet that includes emotional expression. By adding emotional expression to puppets, we aim to foster reflexion and learning about emotions in kids. Our approach minimizes the cost of the digital part of the puppets by reusing the smartphones the parents already have. We argue that when parents buy new phones, they can use their previous ones for the puppets. Since the current phone replacement rate is very high, there are (and there will be) many "old" devices to be reused.

Our future work includes the evaluation of the system with both kids and puppetry actors. We then will improve the system taken into accounts the evaluation results. We also plan to add new features to the system, such as the ability to personalize the puppet face.

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