The Art of Designing Robot Faces – Dimensions for Human-Robot Interaction

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ABSTRACT

As robots enter everyday life and start to interact with ordinary people [5] the question of their appearance becomes increasingly important. A user's perception of a robot can be strongly influenced by its facial appearance [6]. The dimensions and issues of face design are illustrated in the design rationale, details of construction and intended uses of a new minimal expressive robot called KASPAR.

Categories and Subject Descriptors

I.2.9 [**Artificial Intelligence**]: [robotics]

General Terms

Design

Keywords

Human-Robot Interaction, Robot Face Design

1. FACES

Humans are extremely sensitive to the particular pattern of features that form a face. Faces help humans to communicate, display (or betray) our emotions, elicit protective instincts, attract others, and give clues about our health. Several studies have been carried out into the attractiveness of human faces, suggesting that symmetry, youthfulness and skin condition are all factors. Famously Langlois and Roggman [7] proposed that an average face - that is, a composite face made up of the arithmetic mean of several individuals' features - is fundamentally and maximally attractive.

1.1 Are Faces Useful?

Faces are the focal point of any humanoid robot, but in general they are hard to make look realistic, and even if they do the illusion is often shattered once they move; they are complex, requiring many degrees of freedom (DOFs); they are expensive to make and maintain, and they are arguably the part of the robot most likely to pull the rest into the uncanny valley [10, 8]. However there are several good reasons for their use:

1. Expressions are a widely-used feedback mechanism and are easily understood by a human interaction partner [3].
2. A face gives the user an understood focal point for interaction. A face *affords* interaction (cf. [11]).
3. A face can present visual cues to help the user understand the robot's capabilities. Clearly-presented communicative features will encourage intuitive interaction. In addition the design of the face can give clues as to the ability level of the robot; a two-year old face implies two-year old cognitive and manipulative abilities [1].
4. Variable expressions can assist the robot in its role; for instance a face might allow a security robot to look friendly or intimidating as required, or allow a toy robot to look cute or express surprise in interaction games.

1.2 The Design Space of Faces

So how should faces look? Despite the enormous variety in real human faces, most people are intuitively aware when something looks unusual. Cartoons on the other hand, using merely representations of faces, can cover a far larger aesthetic range. In his book *Understanding Comics* [9], Scott McCloud introduces a triangular design space for cartoon faces (Fig. 1). The left apex is *realistic*, i.e. a perfect representation of reality, for example a photograph. Travelling to the right faces become more *iconic*, that is, the details of the face are stripped away to emphasise the expressive features. Towards the top apex representations become *abstract*, where the focus of attention moves from the meaning of the representation to the representation itself. Examples in art would be (to a degree) Picasso's cubist portraits or the art of Mondrian. We can use the design space of faces in comics and narrative art to explore the design space of believable robots [4].

2. KASPAR

Fig. 2 shows KASPAR (**K**inesics **A**nd **S**ynchronisation in **P**ersonal **A**ssistant **R**obotics). KASPAR is a child-sized robot which will act as a platform for HRI studies, using mainly expressions and gestures to communicate with a human interaction partner. The robot is work-in-progress with a 8DOF head and a static body already completed. When finished it will comprise also two 6DOF arms mounted on

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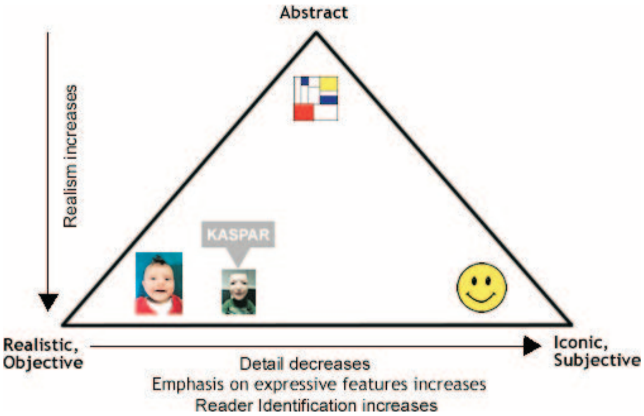

Figure 1: The design space of faces in comics and narrative art (modified from [9]).

Figure 2: KASPAR, showing some expressions: (left-right) happiness, displeasure, surprise.

the child-mannekin torso. The degrees of freedom and feedback options were purposefully limited to reduce ambiguity in experiments, and in order to see what level of HRI can be achieved with minimal expressive and gestural capabilities.

2.1 Design Motivations and Rationale

The design rationale for Kaspar included consistency of appearance and complexity between the head, body and hands to aid natural interaction, and also minimal expressive features to create the impression of sociability as well as autonomy by (for instance) allowing joint attention or expressing internal states dynamically via body kinesics [12] including body movements and facial expression. By keeping the complexity and DOFs down we aim to reduce building and maintainance costs while still creating a robot capable of a wide range of behaviours. The goal in this case is not perfect realism, but optimal realism for rich interaction.

2.2 Face Design

The face design echoes the overall rationale, in that it aims to approximate the appearance and movements of the human face without venturing into ultra-realism. With reference to McCloud's design space the face is realistic but somewhat iconic (see Fig. 1), a design decision which was made with a two-fold purpose. Emphasis on the features used for communication allows the robot to present facial feedback clearly, by allowing the interaction partner to focus on the message more than the medium. Furthermore a reduction in detail de-personalises the face and allows us to project our own ideas on it and make it, at least partially, what we want it to be. These are both potentially desirable features for a robot in HRI scenarios. For the skin a resuscitation doll mask was found to be ideal, providing an appropriate level of aesthetic consistency and detail. The mask is only fixed at the ears and mouth, and allows the face to be pulled into some fairly natural-looking expressions (Fig. 2) as the actuation of the mask in one place tends to slightly deform other areas; for instance, a smile also pushes up the cheeks and narrows the eyes. This is usually considered an 'honest' smile compared to one using only the mouth [2].

2.3 Potential Uses

KASPAR can be used to study a variety of research issues relevant to HRI such as interaction dynamics, gesture creation and recognition, joint attention, communication through imitation and the use of expressions. The addition of arms will allow a range of interaction games to be played.

2.4 Conclusions

Robot design affects users' perceptions in significant ways. Consideration of design issues from psychological studies, work on narrative art design, and recent HRI studies strongly influenced our creation of a minimally expressive humanoid face, part of the robot KASPAR. Dimensions of face design were discussed with aims to help researchers and designers understand and exploit some ideas synthesizing those of artists, roboticists, and psychologists that pertain to human perception of robot faces in HRI.

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