# A Face for a Humanoid Robot

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**The Problem:** To date neither Cog nor Lazlo have faces. Our goal is to design and fabricate an iconic, humanoid face for each robot that fosters a suitable social contract between the robot and humans. Another goal of this project is to shift the robot aesthetic to a design language that utilizes strong curvilinear and organic forms through state of the art design processes and materials.

**Motivation:** Empirical studies have shown that a face characterizes a large part of personality [1]. Therefore, a humanoid robot face plays a paramount role in establishing the social contract between the robot and the humans with which it interacts. We hope to attain an iconic, gender and race neutral face that will place the viewer's developmental expectations of the robot at approximately the level of a child of 5 to 6 yearsof age.

**Previous Work:** Previous work with humanoid robot faces tends to lie along a spectrum ranging from highly consistent realism [2] to a caricature of the human face, stressing the social role to be played by the robot [3].

**Approach:** Our design process uses solid and surface modeling and stereo lithography. This is advantageous because alternative methods such as sculpting or sketching fail to effectively integrate mechanical concerns. They are prone to stereotyping on the part of the artist. Using solid and surface modeling CAD software permits us to explore many design alternatives rapidly. Additionally, stereo lithography allows us to fabricate smooth, curvilinear surfaces.

In addition to creating an accurate model of the robot head (i.e . a mechanical representation including cameras, motors, mounts, and axes), we have created a solid CAD model of Cog with its actual proportions, degrees of freedom, and joint movements. The face under design can be viewed on this model of Cog for evaluation of proportions and visual impact.

We have sent our first version of the face (see Figure 4) through the SLA fabrication process and are presently assembling it on Cog to further evaluate it. In parallel we are conducting studies with the public to assess their perception of personality. This is reported in [4].

**Difficulty:** Our approach presents challenges with respect to our methodology of fabrication and our goal of placing Cog's developmental age at around 6 years.

Using SLA for this application is novel. We are acquainting ourselves with two key aspects of the process. First, the SLA manufacture process constrains the type of designs which are both structurally sound and suitable for casting. This constrains and complicates the software steps. Second, there is expertise involved in obtaining designs that are easily and inexpensively input to the SLA fabrication process.

Unfortunately, the mechanical structures necessary in building robots often force anatomical distortions and disproportions that work against the desired social contract. As Figures 2 and 3 suggest, Cog's existing body is more easily construed as a large, adult male than that of a young child. Consequently, the humanoid face assumes the role of compensating for the disproportionate scale of the body. At the same time it must set the viewer's expectation for the social ability and the physical ability of the robot to be commensurate with the robot's capabilities. Thus the humanoid face plays a pivotal role in counterbalancing the proportions that oppose the designated social contract.

An important consideration for us, then, is selecting the basis feature around which to scale the rest of the head. We chose to use the overall head size to imply the correct mass relationships with the rest of the robot body. Using the crown to jaw height, and the temple to temple width, we closely matched the head proportions to that of the 99th percentile man.

The eyes are largely the focal point in human-robot social interaction, and the saliency and proportion of the eyes are crucial. Discrepancies from the proportions of humans tend to appear either as cartoon caricature or as oddly unsettling realism. Our choice of inter-ocular distance helped achieve a balance between these extremes.

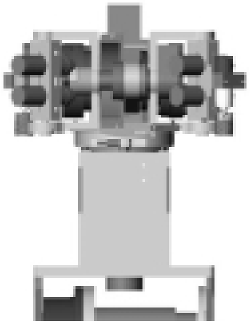

Figure 1: The head of Cog without a face.

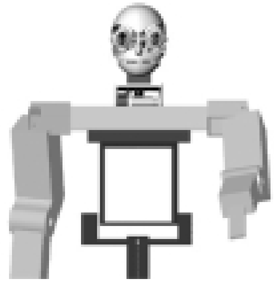

Figure 2: Cog's present torso and the new face.

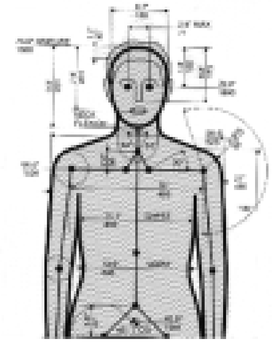

Figure 3: A 99th percentile male.

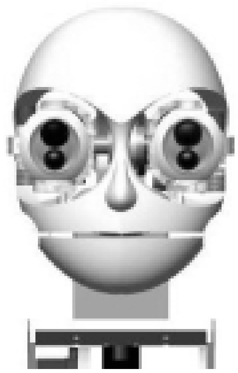

Figure 4: The first prototype of Cog's face as implemented via solid modeling. This is a SolidWorks image.

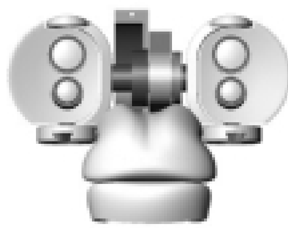

Figure 5: The caricature version of the eye surrounds combined with a monkey like jaw.

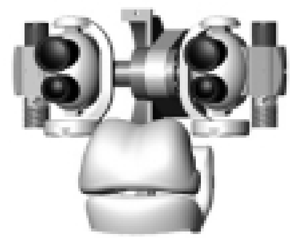

Figure 6: A monkey like jaw combined with an early version of the eye surrounds that was smaller and more oval.

**Impact:** Our use of solid modeling and stereo lithography process has proven to be essential to our quest for a iconic human-like face. With a well designed face, Cog will be able to convey an appropriate social aspect. This will assist Cog in regulating interaction, receiving appropriate stimulus and, in the longer term, learning imitation tasks.

**Future Work:** This work is ongoing. The face needs additional features such as lips, ears, eyebrows and lashes. We also intend to conduct experiments to test the role of the designed face in establishing the desired social contract.

**Research Support:** Support for this research is provided by NTT.

**References:**

[1] B. Reeves and C. Nash The Media Equation, Cambridge Univ. Press, 1996.

[2] F. Hara, H. Kobayashi, F. Iida, and M. Tabata Personality characterization of animate face robot through interactive communication with Human *1st Int'l W/S in Humanoid and Human Friendly Robots*, pg 1-10, 1998.

[3] C. Breazeal. Sociable Machines: Expressive Social Exchange Between Humans and Robots *Ph.D. Thesis*, MIT, 2000.

[4] U.M. O'Reilly and C. Breazeal MIT Lab Abstracts Booklet, 2000.