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At Least, Be Human: Humanizing the Robot as a Medium for Communication

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Abstract. This work presents accessibility as a way to humanize social robots while enabling robot-mediated communication for human-human interaction. A central tenet of human-robot interaction research is to humanize robots as collaborators and companions. Literal approaches to humanizing, either through human-like behaviors or humanoid embodiments, pose technological and social challenges that have prevented adoption of robots in everyday contexts. Even if convincingly humanized robots could be achieved, human-robot interaction may enable an escapism that diminishes our capacity for human-human interaction. I propose to avoid these pitfalls by humanizing the robot as a medium for communication through accessibility. Accessibility humanizes technology by making inner workings visible and familiar to human users, promoting understanding of technological processes and imperfections. Accessibility also enables broader demographics of lay users to become involved with robotics, enabling communication *through* robots, from development processes (e.g. physical and behavioral design) to applications (e.g. telepresence). I use the open-source Blossom social robot as an extended case study of this approach and detail its technical implementations and research deployments.

Keywords. human-robot interaction, robot-mediated communication, accessibility, design, artificial intelligence, telepresence

1. Introduction

Across several definitions of social robots [2,3,4,5], a prevailing notion is the humanizing of robots to facilitate social interactions. Humanizing is often interpreted literally as achieving either human-like intelligence or lifelike humanoid embodiments [6,7]. However, these approaches pose large technological and social challenges. Consumer social robots (e.g. Anki's Cozmo and Vector [8], Jibo [9], Kuri [10]) have had difficulty finding commercial success; this may be attributed to the high expectations for interaction – often set by fiction [11,12] – that are difficult to meet. The challenging expectations of literal humanization have limited acceptance of social robots in contexts beyond controlled research settings. Even if sufficiently capable robots could be realized, human-robot interaction may yield scenarios that, like other consumer-oriented technologies

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such as mobile computing and entertainment media, negatively affect our capacity for human-human interaction.

In this work, I propose an alternative approach to humanizing robots through accessibility. Accessibility can enable lay users without prior robotics experience to familiarize themselves with typically esoteric aspects of robotics, such as the design of hardware and behaviors. In contrast to typical human-robot interaction scenarios, which involves users communicating *with* a robot, accessibility can reframe the robot as a medium *through* which users communicate. In this article, I use the open-source Blossom social robot as an extended case study and frame phases of its development – physical design, movement authoring, and application as a telepresence medium – as forms of robot-mediated communication that enable human-human interaction.

2. Preliminaries and Definitions

In this section, I provide definitions for key terms – humanizing, medium, and communication – and arguments for pursuing accessibility as a humanizing element for robots.

2.1. Humanizing the Robot

The proposed approach to humanizing robots through accessibility begins with Mori's *bukimi no tani* (不気味の谷, "the valley of eerieness"), anglicized as "the uncanny valley." Originally in reference to the design and movement of prostheses, the phenomenon refers to slightly imperfect approximations of human features eliciting a pronounced sense of unease. The graph's horizontal and vertical axes, originally *ruijido* (類似同, "degree of similarity") and *shinwakan* (親和感, "fellowship feeling"), are anglicized as "human likeness" and "affinity," respectively. "Affinity" is a notion similar to familiarity[2], and is defined as "a liking for or an attraction to something; a quality that makes people or things suited to each other" [15]. I argue that a "human" before "affinity" may have been lost in translation; reintroducing it yields "human affinity," which I equate to the definition of "humanizing." Thus, to humanize is to increase the feeling of human affinity and familiarity, which I interpret as maximizing the vertical position on the uncanny valley graph (Figure 1, green arrow).

Due to the difficulty of literal humanization through human-like behaviors and embodiments, I propose to humanize robots through zoomorphism and accessibility. In the uncanny valley graph, the "stuffed animal" region of zoomorphic likeness lies at a local maxima of affinity before the fall into the valley. Though it seems counter-intuitive to humanize through non-humanoid zoomorphism, we often humanize animals and anthropomorphize personal belongings, e.g. musical instruments and vehicles [17]. Darling argues that zoomorphism can realign expectations for interaction while drawing upon our historical relationships with animals [18]. Accessibility can increase familiarity by making the robot's inner workings visible and understandable to lay users without prior robotics experience. This notion of humanizing through accessibility is echoed in post-digital aesthetics [19,20,21], which humanizes technology by making processes familiar to users, embracing imperfections, and emphasizing the humanity of the technology's

[2] The first character of *shinwakan*, 親, connotes "familiarity." MacDorman interpreted *shinwakan* as "familiarity" in his initial 2005 translation [13], then as "affinity" in his updated 2012 translation [14].

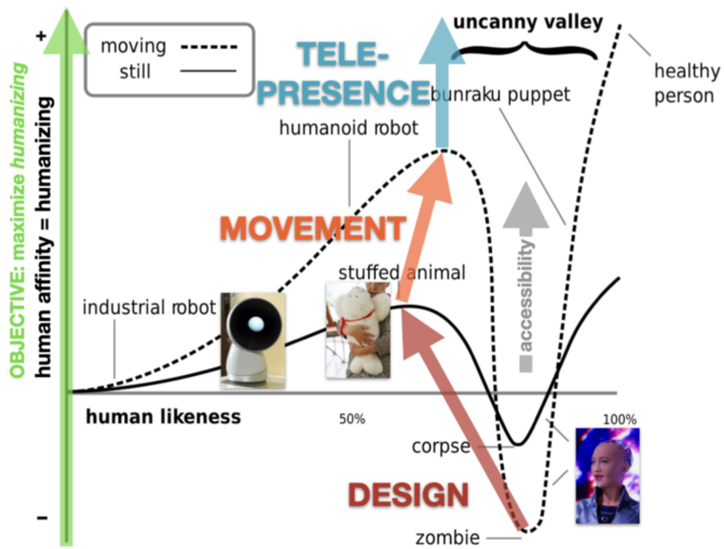

Figure 1. The proposed approach for humanizing the robot, referencing Mori's *bukimi no tani* (不気味の谷, "the valley of eerieness," anglicized as "the uncanny valley") as a conceptual framework [16]. I equate "humanizing" with maximizing "human affinity" on the vertical axis of the graph (left green arrow), and journey out of the valley by making accessible (gray arrow) three phases of robot development: design, movement, and telepresence.

creators and users. Šimbelis' thesis, titled *Humanizing Technology Through Post-Digital Art,* presents several examples of post-digital works, such as a robotic painting mechanism with imperfect analog user interfaces such as breath controlled inputs [22]. Post-digital's emphasis on processes draws attention to technological mediums, inviting interpretation of robots as mediums themselves.

2.2. *Medium for Communication*

While robots in social contexts are typically interpreted as independent agents *with* whom we communicate, accessibility can frame robots as technological mediums *through* which we communicate. Mediums can be any technology that enables communication, such as telephones which communicate auditory messages or photographs which communicate visual information; this relationship is formalized in Shannon's model of communication, wherein a message is encoded and decoded through a medium [23]. McLuhan, in declaring "the medium is the message," argued that the mediums themselves and their ecological effects on human communication are more important than any communicable message (e.g. a particular phone conversation, a specific photograph of an event) [24]. Hoorn has applied existing theories of computer-mediated communication in the context of robots as two distinct modes: human-robot communication (*with* the robot) and robot-mediated communication (*through* the robot) [25].

McLuhan also argued that the effects of mediums simultaneously extend and amputate our capacity for communication. The mobile smartphone extends our social connectivity but amputates our capacity for face-to-face communication; the photograph extends our visual communication but amputates our visual memory through the phototaking-impairment effect [26]. Critics of social robots argue that robots pose similar risks for amputation, particularly in human-robot communication scenarios. Turkle recounts users willing to replace their human partners with agreeable robots, becoming dependent on robots for matters as personal as health, or creating robotic replacements for the deceased [27]. Other scholars have argued that offloading human interactions to robots (e.g therapy, caretaking) may be dehumanizing for vulnerable populations [28,29]. The potential social amputations of human-robot communication enable escapism from difficult human-human interactions towards the refuge of robots that neither tire nor disagree.

The robot-mediated communication mode offers opportunities for extending human-human interaction, particularly through the robot's unique affordance of physicality. Though telepresence is the canonical use case of robot-mediated communication, accessibility enables communication through other aspects of the robot, such as the design of its physical embodiment or the authoring of its behaviors. Users can convey diverse interpretations through accessible robot design, challenging notions of how robots *should* be by imagining how robots *could* be.

As an extended case study of this approach, I provide example deployments of the open-source Blossom social robot and detail three phases of its development: design, movement, and telepresence (Figure 2). We first move out of the valley through an open-source zoomorphic design; accessible design enables lay users to communicate their notions of robot design through customization. We next move further up through movement authoring that enables intuitive programming of robot behaviors; accessible programming enables lay users to communicate their interpretations of appropriate robot behaviors through high-level programming. We finally move beyond the peak through embodied telepresence; accessible telepresence enables lay users to communicate their physical presence at a distance. Blossom's journey out of the uncanny valley reframes phases of robot development as opportunities for robot-mediated communication and culminates in an application for human-human interaction.

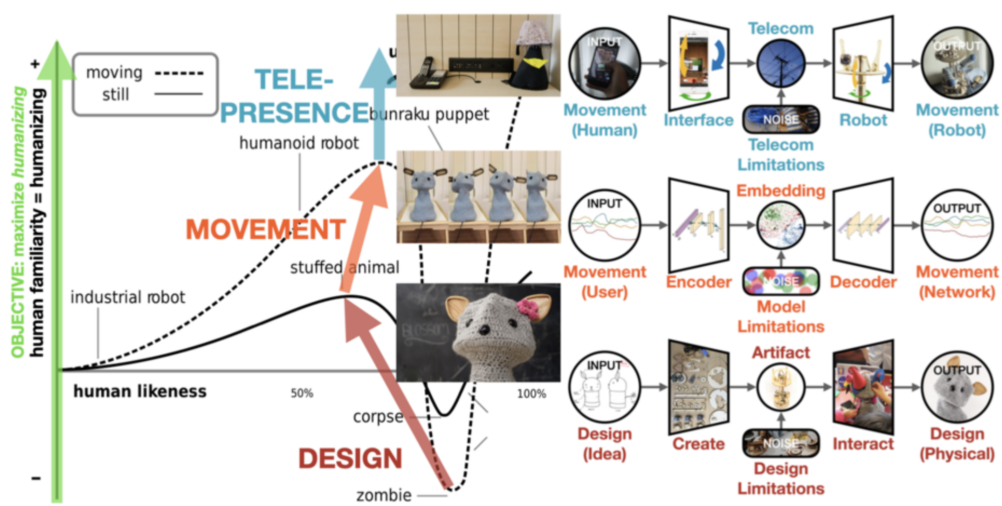

Figure 2. Blossom's journey out of the uncanny valley (left) and interpretations of each phase (design, movement, telepresence) as forms of robot-mediated communication, as formalized through Shannon's model of communication (right) [23].

3. Implementation on the Blossom Robot

In this section, I discuss three phases of Blossom's development – design, movement, and telepresence – and how each phase humanizes the robot through accessibility and robot-mediated communication. I provide overviews of the technical implementations and research applications.

3.1. Design

Blossom's design is accessible through its open-source interior mechanism and user-customizable exterior (Figure 3, center) [30]. The interior mechanism is constructed from laser cut wood and consists of a head platform suspended with rubber bands from a central tower component (Figure 3, left). Motors at the bottom of the tower actuate the head by reeling in strings attached to the head platform. The tensile components achieve a large range of motion and passively smooth, lifelike movement, similar to the squash-and-stretch and follow-through principles of animation [31]. The base robot features four degrees of freedom (roll, pitch, yaw, vertical translation); users can attach additional motors for appendages such as ears and arms. The exterior is made of soft fabrics that are crafted by the user, inviting a broader range of users to be involved in robot building. We have deployed Blossom in several scenarios, ranging from demonstrations at technology exhibitions to in-depth robot-building workshops, where students (adolescents aged 10-13) worked in groups to build the interior mechanism, customize the exterior (Figure 3, bottom right, top row), and choreograph robot movements to videos. Other researchers have created Blossoms for their own applications (Figure 3, bottom right, bottom row), including using Blossom as a canvas for exploring robot clothing [32].

In the way that Norman frames artifacts as the mediums through which designers indirectly communicate with their users [34], Blossom as an artifact communicates several

Figure 3. Annotated portfolio [33] of Blossom and the aesthetic concepts that inspired its design.

aesthetic concepts that inspired its design. Elements of post-digital design are present in the imperfect hand-crafted elements and blending of analog and digital mediums (elastics and wood merged with motors and microcomputers). Related to post-digital is *kintsugi* (金継ぎ, "golden repair"), a Japanese aesthetic that embraces imperfection by celebrating repair and our enduring relationships with objects [35]; this notion is reflected in the design's repairability. The use of unconventional materials and resulting "non-robotic" embodiment appeal to tenets of critical design, a way to challenge preconceived notions of products and their roles in our lives [36].

Blossom's design also pays homage to the history of robots. W. Grey Walter, a psychologist who created the robotic tortoise progenitors of modern robots, found that even simple behaviors of attraction or repulsion from light sources resulted in lifelike behaviors, enough for Walter to name the robots Elmer and Elsie [37]. Similarly, though Blossom is reducible to a simple assembly of motors and subroutines, the resulting expressiveness and lifelikeness suggests more than the sum of its components belie. Drawing from Walter Benjamin's *The Work of Art in the Age of Mechanical Reproduction* [38], and in contrast to the prototypical robot as both reproduction and reproducer, each Blossom's existence as a unique instantiation of the base robot imbues the artifact with an "aura," the unique spatiotemporal quality lost with the commodification of mass-produced consumer objects.

Beyond roboticists and designers, lay users can communicate their interpretations of robot aesthetics through Blossom's design (Figure 2, bottom right). In the deployments, participants worked together to create various robot aesthetics related to personal interests, such as their favorite media and hobbies. Users also projected their ideal capabilities of the robot through aesthetic extensions, such as legs for locomotion or other functional appendages (e.g. arms, tails). The accessibility of the design extends from its physical construction to the authoring of movements.

3.2. Movement

Blossom's movement is accessible through its motion-based smartphone interface (Figure 4) [39]. Unlike traditional robot movement authoring systems that require domain

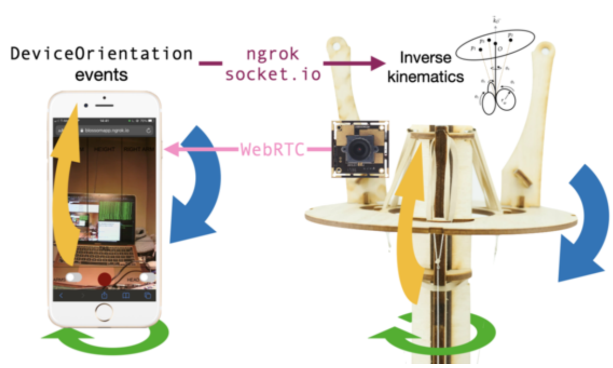

Figure 4. The movement authoring system. Users move the phone (left), and the `DeviceOrientation` motion events are transmitted through `ngrok` and `socket.io` to the robot. The robot's back end inverse kinematics model calculates the motor positions required to match the phone's pose. For the telepresence application, `WebRTC` transmits a first-person video feed from a wide-angle camera embedded inside the robot's head to the phone interface.

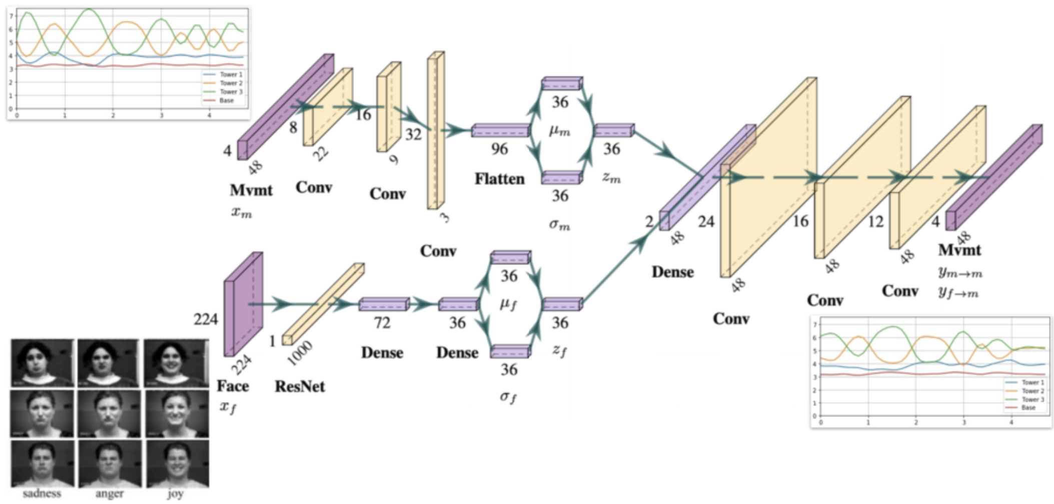

Figure 5. One of the behavior generation neural network models: a face→movement translation network. The movement variational autoencoder (VAE) learns compressed representations z_m of the original movements x_m (top left to right). An additional ResNet-based image encoder (bottom left) compresses images of facial expressions x_f into the shared latent space $\{z_m, z_f\}$. Once the end-to-end network is trained, the model can generate new movements y_m by sampling from z_m and passing through the movement decoder (top left to right) or translate faces into movements y_f by passing images through the face encoder and movement decoder (bottom left to right).

knowledge (e.g. motion planning algorithms, manual robot operation techniques), the smartphone interface is familiar to users without prior robotics experience. The interface transmits the phone's motion data to the robot's host computer, which then calculates the motor positions to match the robot's head orientation to the phone's orientation. Using this interface, we crowdsourced movement samples from lay users by asking them to puppeteer the robot as if it were conveying a range of emotions (happiness, sadness, and anger, as based on Ekman's emotions [40]). We used the crowdsourced movements as inputs for behavior generation models based on encoder-decoder neural networks, specifically variational autoencoders (VAE) [41] (Figure 5). Once trained, the models can generate new movements, modify the emotive quality of existing movements [39], and translate affective inputs (e.g. facial expressions) into emotive movement responses.

Blossom's accessible movement authoring system enables users to communicate their interpretations of robot behaviors (Figure 2, middle right). Unlike closed-source robot systems that may become repetitive and predictable, enabling users to "teach" new behaviors iteratively expands and personalizes its behavior library. The encoder-decoder compression of the neural network model is analogous to the mediation of Shannon's communication model. By extending the movement control system with remote access, we enable real-time human-human communication through Blossom's telepresence capabilities.

3.3. Telepresence

Similar to movement, Blossom's telepresence functionality is accessible through the ease of use of its interface [42]. Users can access the interface remotely through a mobile browser with no additional software. A wide-angle camera in Blossom's head streams a first-person video feed to the phone, enabling remote users to view the space as if they were embodying the robot (Figure 4, left). We have used the system in human evaluations (N=30) where users remotely controlled the robot to create movements to expand the behavior dataset [43]. We varied the viewpoint between either first-person (internal video *from* the robot, viewed on the phone interface) or third-person (external video *of* the robot, viewed on a separate desktop browser interface) perspectives. We found large preferences for the third-person perspective, though the COVID-mandated restrictions on research prevented us from evaluating the system in human-human interaction scenarios preferable in the first-person perspective.

Blossom's accessible telepresence is the most direct example of robot-mediated communication between human users (Figure 2, top right). Unlike screen-centric telepresence robots with button- or joystick-based interfaces that abstract users away from their own embodiment, Blossom's motion-centric embodiment and interface emphasizes the remote user's physicality.

4. Discussion

In contrast to the bulk of robotics research which focuses on utilitarian applications, this work interprets the robot as a medium that can enable forms of human communication. As with any medium, robots may eventually be used for creative expression, capable of communicating artistic messages beyond the design and movement affordances discussed here. Though many have used robots for creative applications [44], the technological inaccessibility of robots has rendered such works niche and sparse, with no unified theory or guidelines for practice. Expanding the accessibility of robots to demographics beyond roboticists and researchers will enable exploration of the robotic equivalents of tools (e.g. a writer's pen, a photographer's camera) and techniques (e.g. linguistic grammar, photographic composition) that yield theories and works of artistic expression through robots.

5. Conclusion

I presented accessibility as an approach for humanizing the robot as a medium for communication. Drawing from the concept of the uncanny valley, I defined humanizing as an effort to maximize familiarity of robots to human users. Familiarity through accessibility can humanize robots by making their inner workings visible and foregrounding the human elements of their construction and use. I presented case studies for this approach using the Blossom robot and detailed how three phases of its development – design, movement, and telepresence – were made accessible and enabled users to communicate through the medium of the robot. I hope that this work inspires future roboticists and researchers to explore accessibility and alternative approaches to humanizing robots as mediums for human-human communication.

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