From Anime To Reality: Embodying An Anime Character As A Humanoid Robot

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ABSTRACT

Otaku is a Japanese term commonly associated with fans of Japanese animation, comics or video games. Otaku culture has grown to be a global phenomenon with various hobbies and media. Despite its popularity, research efforts to contribute to the otaku culture have been modest. Therefore, we present Hatsuki, which is a humanoid robot that is especially designed to embody anime characters. Hatsuki advances the state of the art as it: 1) realizes aesthetics resembling anime characters, 2) implements 2D anime-like facial expression system, and 3) realizes anime-style behaviors and interactions. We explain Hatsuki's design specifics and its interaction domains as an autonomous robot and as a teleoperated humanoid avatar. We discuss our efforts under each interaction domain, and follow by discussing its potential deployment venues and applications. We highlight opportunities of interplay between otaku culture and interactive systems, potentially enabling highly desirable interactions and familiar system designs to users exposed to otaku culture.

CCS CONCEPTS

• **Applied computing** → Arts and humanities; Media arts; • **Computer systems organization** → Embedded and cyber-physical systems; Robotics; • **Social and professional topics** → User characteristics; Cultural characteristics.

KEYWORDS

Design, Robot, Interaction, Anime, Manga, Otaku, Media, Humanoid, Culture

1 INTRODUCTION

Otaku is a Japanese term that refers to fans of specific subculture, especially Japanese anime culture (Japanese Cartoons). The otaku culture has been rising in popularity worldwide, where various events and local communities were created around related hobbies and activities [1]. Anime figurines comprise an essential part of otaku culture, which present miniature embodiment of characters from popular otaku media, like anime, manga, or video games.

Despite the worldwide popularity of the otaku culture, research had minimal contributions to develop systems or interactions inspired by the otaku culture. For example, existing research that combines the otaku culture and robotics is limited; it mainly focuses adult-size humanoid robots that lack anime-like facial expressions, body proportions or lack anime-like behaviors and interactions [7, 8].

To bridge this gap, we present Hatsuki (Figure 1), a humanoid robot that embodies an anime-character. Hatsuki's novelty lies in its unique design considerations that reflect anime characters, which are: 1) An aesthetic design that resemble anime characters, 2) 2-dimensional anime-like facial expressions, and 3) ability to deliver anime-style behaviors and interactions. The embodiment of these design considerations allows Hatsuki to provide rich interaction experiences resembling anime characters beyond what have been explored. To the best of our knowledge, Hatsuki is the first humanoid to embody all mentioned design considerations.

We briefly explain the design and implementation of Hatsuki, and present the potentials of using Hatsuki in two interaction domains: 1) Hatsuki as an autonomous robot, where we implemented a machine learning (ML) method to enable autonomous life-like expressions and interactions. 2) Hatsuki as an avatar, where Hatsuki serves as a teleoperated avatar that can provide anime-style embodiment for remote performers or casual users. We follow with a discussion of the potential in exploiting the familiarity and popularity of otaku culture to deliver engaging systems and user experiences.

Figure 1: Hatsuki is an anime-like humanoid robot with rich anime-based expressions and behaviors

This work expands our previous report [2] by demonstrating Hatsuki's novel design and interaction potentials in various contexts and interaction domains, with the hope of inspiring researchers to explore intriguing applications and systems that target or base their designs on the otaku culture, similar to Hatsuki.

2 RELATED WORK

Previous researchers have investigated various forms of humanoid robots that are designed for indoor daily life support [3]. Geminoid [4] extends humanoid robots' aesthetics by focusing on a realistic human-like appearance and behavior. However, despite its realistic human-looking aesthetics, many of those humanoids suffer from uncanny valley [9], which repels people from the robot. Additional efforts focused on designing robots for entertainment, like singing and dancing [7, 8]. Although these works embody doll-like aesthetics, these robots are limited as they lack anime-like facial expressions, speech, or autonomous interactivity. Further works are done within animatronics, which are electro-mechanically animated robots that realistically mimic characters or creatures [5]. Animatronics are common in movies and entertainment attractions, where they can represent humans or animals to entertain visitors in various shows   [5].

Compared to previous works, Hatsuki advances the state of the art by taking a different embodiment approach. Hatsuki's design emphasize an anime-character' aesthetics, proportions, behaviors, and emphasize entertainment applications related to the otaku culture. Such thorough embodiment of anime-character attributes paves the way for intriguing research and application directions beyond previous works.

3 THE DESIGN AND IMPLEMENTATION OF HATSUKI

We utilized an outside-in iterative design process to design Hatsuki, which first emphasized the overall exterior and aesthetic design, and then considered internal system and mechanical design. Therefore, Hatsuki realizes three main design factors 1) Hatsuki's aesthetics are designed to resemble mecha-musume anime character; a common art style in otaku culture that refers to female characters with mechanized design decorations or body parts. 2) Hatsuki embodies anime-character body proportions. 3) Hatsuki's face implements a rich anime-like expression system. The realization of these design factors enables Hatsuki to advance the state of the art in anime-like humanoid robots beyond previous efforts, and we explain their realization as follows:

3.1 Mechanical Design

As shown in Figure 2 A,B, Hatsuki's proportions were chosen to resemble common anime-character designs. Hatsuki is mainly constructed with 3D printed PLA parts (Polylactic Acid). Hatsuki comprises 17 DoFs; three Robotis XM430 for the head, four for each elbow, and one per wrist. Two Robotis XM540 were used for each shoulder, two HobbyKing HK15148 for the ears-decoration and twelve Futaba S3114 servomotors for the tendon-driven hands. Dynamixel SDK was used to control Robotis servos, while PWM is used to control all others with two Arduino Nano, which in turn are controlled over serial communication through a PC.

3.2 Sensors and Facial-Projection System

Hatsuki's head comprise an rgb-d camera (Intel Realsense D435) generic mic and a speaker (Figure 2 C).

Hatsuki's face is projected using a projector integrated into the back of Hatsuki's head. As shown in Figure 3 B, facial expressions are calibrated and projected to the 3D-printed face as follows: 1) Hatsuki's 2D facial illustration is aligned with the front view of the 3D model of Hatsuki's face. 2) We project the texture on the 3D mesh of Hatsuki's face. 3) We recapture the projected-texture from the back, then show it through the projector.

3.3 Control System

We used a high-spec PC to control our robot, which runs our control software developed in Unity3D and comprises multiple game-scene to control various robotic components (Figure 3 A). We also developed a high-level network interface that enables us to generate and control various robotic animations, facial expressions, voice and integrate inverse-kinematic solvers or other modules as needed. This system is used to realize the interaction experiences in section 4.

The realization of Hatsuki paves the way for exploring various interactive scenarios, such as for singing, dancing, or public performances and service applications. Hatsuki's design can also be customized to resemble other anime characters to suit different deployment contexts.

4 HATSUKI'S INTERACTION DOMAINS

We segregate interaction with Hatsuki under two domains, and we discuss each as follows:

4.1 Hatsuki as an Autonomous Humanoid Robot

In this domain, Hatsuki is expected to provide life-like interactions with people while portraying anime-like expressions autonomously. This presents a challenge for interactive robots in general; as facial expressions and body motions should be adaptive to observed contexts rather than prerecorded ones (which causes the uncanny valley [9]). Therefore, to achieve a fluid and attractive user experience, an essential research direction is to investigate methods of
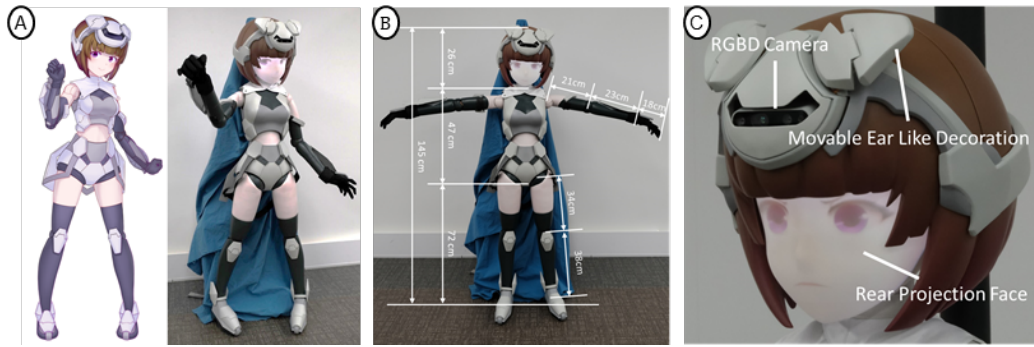
Figure 2: A) Hatsuki's illustration and realization. B) Hatsuki's body proportion follow those of anime-character designs. C) Various componetns and sensors in Hatsuki's head.
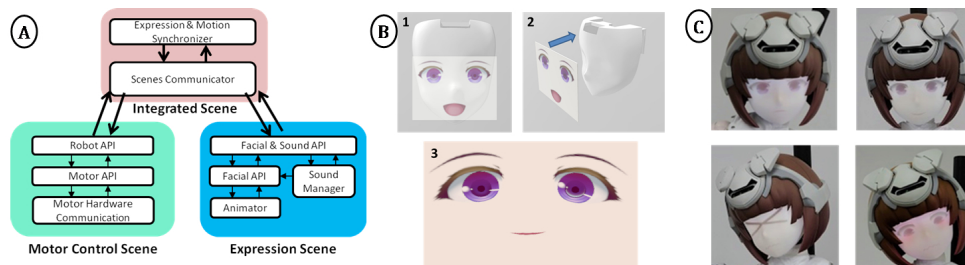

Figure 3: A) Hatsuki's control structure. B) Hatsuki's facial expression system. C) Hatsuki can convey a large variety of anime-inspired facial expressions.
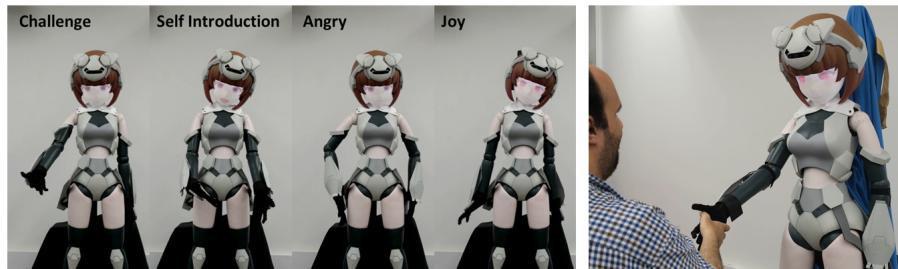

Figure 4: Our implementation of MTRNN enables Hatsuki to express facial expressions and motions in various ways depending on contextual factors, which makes the robot behave in a life-like manner.

conveying context-adaptive facial expressions and motions that mimic life-like ones.

We take the first steps to investigate this domain by developing an imitation learning system with a multiple time-scale recurrent neural network policy (MTRNN) [2]. Although our preliminary work is successful in portraying various facial and body expressions (shown in Figure 4), a deeper and a more generic approach is required to capture further contextual factors and reflect them on facial expressions and behaviors. This research direction is significant; as these methods can be generalized on other domains, like digital avatars in

VR or video games, to portray characters with rich life-like behaviors and expressions rather than pre-recorded animations and rigid expressions.

4.2 Hatsuki as an Anime-Like Humanoid Avatar

Hatsuki can be used to embody vivid characters when teleoperated by performers (e.g. anime voice-actress). Accordingly, we implemented a Leader-Follower system, which includes a VR cockpit that is network connected to the robot control software (Figure 5). We used WebRTC for audio-visual feedback, robotic controls, and a joystick to trigger facial expression. This interaction domain is especially novel when Hatsuki is controlled by a performer, who can realize anime-like interactive characters and deliver entertaining performances.

Anime characters have exaggerated body gestures, and can convey human-like and largely-unrealistic facial expressions surpassing human ones (e,g, Figure 3 C). The large expressibility spectrum

Figure 5: Hatsuki can be teleoperated. Our system uses the operators head and body postures, facial expressions, and voice to control Hatsuki and deliver interactive anime-like performances.
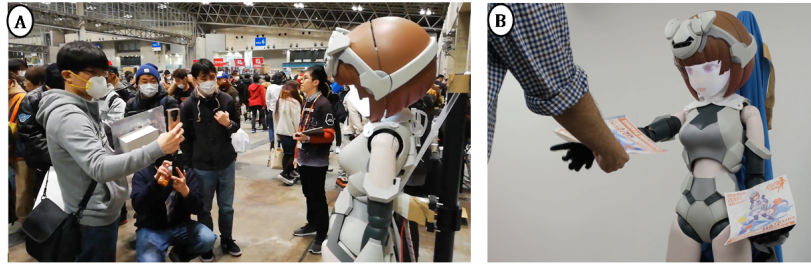

Figure 6: A) Visitors of our booth experienced various interactions with Hatsuki. B) Hatsuki can be used for both entertainment and service applications, such as being as receptionist.

in anime-characters present an unexplored research direction; to investigate implicit methods to convey exaggerated expressions, and to translate human expressions to the larger spectrum of anime expressions.

5 HATSUKI'S DEPLOYMENT AND APPLICATION POTENTIALS

We deployed Hatsuki at Wonder Festival 2020, which is the world's largest anime figurines event. Visitors of Hatsuki's booth were able to interact with Hatsuki in various ways, such as by shaking its hands or posing with it. Also, visitors experienced a short performance that included a basic chat and expressions that highlighted Hatsuki's potential interactions (Figure 6). Similar to previous research [6], user impressions were analyzed and were very positive, and numerous usage scenarios and application contexts were proposed (Discussed in [2]).

Based on results, we believe a key factor of Hatsuki's acceptance is its anime-like design. A critical result of our evaluation indicate that visitors thought Hatsuki is the intersection of an anime-figurine and a robot. Therefore, Hatsuki has high artistic and collectability value similar to those of anime-figurines, while being able to fulfill service and entertainment applications. Our results also show that the appeal of Hatsuki is not limited to current or huge fans of otaku culture, but also to people slightly familiar or previously exposed to the otaku culture. Such finding can be used to deliver interactions based on otaku culture (e.g. anime or video games), that will be familiar to users exposed to such culture. Overall, results indicate

that Hatsuki's anime-based design was very well received and it increased desirability and acceptance of the robot. Nevertheless, there is a dearth of research that base systems or interactions on design elements of otaku culture. Accordingly, we believe it is intriguing to explore designing systems and interactive experiences that use design elements from the otaku culture as foundation to establish familiarity, increase desirability or to explore new application domains.

6 CONCLUSION

This paper presents Hatsuki, a novel humanoid robot with anime like design, facial expressions and behaviors that can provide intriguing interaction potentials under two main interaction domains. The realization of Hatsuki demonstrates the potential of using the familiarity and popularity of the otaku culture to build engaging interactive experiences and systems. By demonstrating Hatsuki, its design methodology and potential applications, we hope our work will inspire further research to advance interaction with novel systems, exploring intriguing applications, and encourage interplay with design elements from the otaku culture as a whole.

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