

# Inclusion in Assistive Haircare Robotics: Practical and Ethical Considerations in Hair Manipulation

Uksang Yoo  
uyoo@andrew.cmu.edu  
Carnegie Mellon University Robotics  
Institute  
Pittsburgh, Pennsylvania, USA

Nathaniel Dennler  
dennler@usc.edu  
University of Southern California  
Computer Science Department  
Los Angeles, California, USA

Sarvesh Patil  
sarveshp@andrew.cmu.edu  
Carnegie Mellon University Robotics  
Institute  
Pittsburgh, Pennsylvania, USA

Jean Oh  
hyaejino@andrew.cmu.edu  
Carnegie Mellon University Robotics  
Institute  
Pittsburgh, Pennsylvania, USA

Jeffrey Ichnowski  
jichnows@andrew.cmu.edu  
Carnegie Mellon University Robotics  
Institute  
Pittsburgh, Pennsylvania, USA

## ABSTRACT

Assistive robot haircare has the potential to alleviate labor shortages in elder and disability care facilities and restore people’s dignity and capability to express their identities freely. We argue that because of hair and hairstyles’ often unique importance in defining and expressing an individual’s identity, we should approach the development of assistive robot haircare systems carefully while considering various practical and ethical concerns and risks. In this work, we specifically list and discuss the consideration of hair type, expression of the individual’s preferred identity, cost accessibility of the system, culturally-aware robot strategies, and the associated societal risks. Finally, we discuss the planned studies that will allow us to better understand and address the concerns and considerations we outlined in this work through interactions with both haircare experts and end-users. Through these practical and ethical considerations, this work seeks to systematically organize and provide guidance for the development of inclusive and ethical robot haircare systems.

## KEYWORDS

Assistive robotics, Personalization, Identity, Ethics, Manipulation

## 1 INTRODUCTION

Because hair plays a uniquely significant role in an individual’s identity and self-esteem [2, 21], robot haircare systems have the potential to restore independence and an ability to express themselves for those with limited mobility [13]. For many aging individuals with a loss of independent mobility, hair care is an increasingly time-consuming and difficult daily task. However, the importance of hair to a person’s self-esteem tends to also increase with age [35]. Because most elder care and hospice facilities heavily rely on volunteers for hair-care assistance [5], there is a strong need for using robotic systems to automate assistive haircare tasks.

Toward addressing the gap in haircare services, researchers have proposed deploying robotic assistance for combing [13, 20]. Assistive hair manipulation and styling present interesting challenges for roboticists such as trajectory planning based on hair flow estimation [13] and sensor-fusion for safe interaction with the head [20]. Addressing this year’s theme of the Conference on Human

Robot Interaction, “HRI in the real world,” we outline some practical and ethical considerations toward developing and transitioning assistive haircare robotic systems from controlled academic settings to the real world.

## 2 BACKGROUND

In this section, we review works relevant to our discussion of robot haircare systems. Inclusive robot haircare systems should consider diverse physical hair types (2.1) as well as the users’ identities (2.2). We also incorporate relevant literature on how identity has been considered in other areas of HRI research (2.3).

### 2.1 Hair Types

Proper categorization of hair’s physical properties can help us develop and study robotic haircare strategies systematically. In the field of assistive feeding, the categorization of food items on the axes of their physical properties has helped to formulate robotic manipulation strategies systematically toward developing more robust robotic agents [3, 15]. By utilizing explicit categories of hair, we could similarly focus our efforts on addressing robotic haircare with diverse hair types.

Early efforts to categorize hair types were built on problematic language and prejudice that conflated the construct of race with hair properties [14]. Such works largely used these hair property categories to define and distinguish racial groups, often with categories that are rejected today.

Since then, researchers have produced various categorization schemes for hair textures and properties [24, 25]. Many of these contemporary approaches to understanding different hair types largely attempt to decouple the notion of race from the physical properties of hair such as its length, cross-sectional thickness, and curliness. Previous works have explicitly recognized the problematic history of hair categorization and actively addressed them in trying to create hair property categorization schemes that are not grounded in racial identities [25]. However, some of the physical properties of hair used in these categorization schemes are still often referenced in racialized contexts in literature [22, 25]. Additionally, the process of developing hair categorization schemes often attempts to collect a representative sample from the global

population [24], which may reflect today’s notion of race and ethnic identity.

## 2.2 Identity Expressions with Hair

An inclusive robot haircare system should not only be able to handle diverse types of hair but also enable the users to express their preferred identities reflected in diverse hairstyles. The way that people style hair has long played a role in defining and expressing national, ethnic, religious, and racial identities [1, 26, 28, 33]. Individuals may also choose to express their sexual and gender identities through hairstyles [8, 27]. Importantly, these identities may intersect and be expressed through external appearance and hairstyle [6].

An individual’s hairstyle also significantly affects what others presume about the individual’s identity, even controlling for other visible features [32]. While a component of such social interaction with hairstyle can be an individual’s avenue for identity expression [27], it can also be a source of prejudice and oppression [7]. For instance, there is an active call to protect the freedom to express one’s identity through hairstyle in the United States [19]. Such struggles provide social context for the development of an inclusive robotic haircare system that can not only handle diverse hair types but also enable users to express diverse preferred identities through hairstyles.

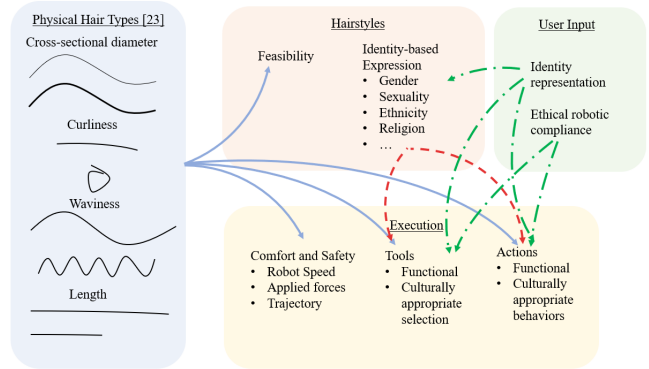
## 2.3 Identity-based Personalization

Researchers in both Human-Computer Interaction (HCI) and HRI have studied various approaches to identity-aware and identity-based personalization of user experience. Such approaches have sometimes called to explicitly consider the user’s race [23] or gender [10, 29]. Some researchers argue that explicitly considering the user’s identity to personalize robotic interaction experiences can result in improved efficacy and enable effective consideration of cultural differences [17]. Linking identity to a user can affirm their identity, reduce identity erasure, promote equitable resource allocation, and reduce the chance that a user may experience content that causes dysphoria [12]. Additionally, broader frameworks such as Design Justice argue that we should explicitly consider groups of people that benefit from and experience the burden of systems [9].

There has also been a criticism of identity-based personalization because explicitly classifying the gender or race of the user could lead to reinforcing harmful norms or cause harm by misidentifying the user’s identity [37]. Interviews with developers and users of AI systems have qualified that systems collecting explicit representations of identity should be optional, mutable, and revocable at any time [12]. Whether we explicitly or implicitly consider the user’s identity is a naturally relevant topic for the development of robot haircare systems because of hairstyle’s link to identity expression.

## 3 CONSIDERATIONS

In this section, we list and briefly outline the considerations we believe should be incorporated into the development of an inclusive and ethical robot haircare system as outlined in Fig. 1. Toward inclusion, we should consider how we can ensure that the developed robot haircare system can address diverse hair types (3.1) and allow comfortable expression of the user’s identity (3.2). Additionally,



**Figure 1: Functional diagram of the practical and ethical considerations for robot haircare system development. The physical hair type directly determines the space of feasible hairstyles. Additionally, it affects what robot speeds, applied forces and trajectories are physically comfortable for the users. It also affects what tools can be used and what robot actions are effective. Identity-based expression through hairstyles partially determines the culturally appropriate tools and actions the robot can perform. The user input of identity directly relates to the consideration of hairstyles that reflect the user’s expressed identity. The user’s identity input and which user commands the system determines are ethical to comply with relate to the concerns of culturally appropriate tools and actions that the robot should use.**

we must consider the possible barriers to adoption rooted in the system’s associated costs and economic disparities (3.3). Through the system development, we should also consider the potential risks of some design choices such as user identity representation, and minimize harm (3.4).

### 3.1 Hair Types

Categorization of the physical properties of an individual’s hair can provide guidance and structure to systematically develop robotic haircare strategies that can be functional with diverse hair types. Crucially, we can make an effort to not explicitly consider race at the perception level by utilizing categorization schemes of hair types grounded directly on individual hair’s physical properties as opposed to the user’s perceived or self-identified ethnicity. A well-grounded categorization of the user’s hair is a necessary step to develop a robot haircare system that can effectively manipulate diverse types of hair. For example, a manipulation strategy to comb straight hair has the potential to permanently damage hair structures in curly hair. Employing tools like counterfactual reasoning helps eliminate biases from learning-based systems as shown in [36, 38], enabling the development of effective characterization schemes. These effective categorization schemes for hair types can help the system designers systematically discover gaps in the robotic system’s covered serviceable population. Additionally, the categorization of hair types also informs admissible actions, relevant transition models, and manipulation strategies that the assistive haircare robot can perform. The hair type also defines the

space of feasible hairstyles that the user can hope to achieve with the system.

### 3.2 Identity-based Expression and Preferences

When exploring the space of feasible hairstyles defined by the hair type, we should explicitly consider identity-expressive hairstyles to ensure that they are appropriately represented in the design of the system. In addition to the hairstyle that the robot haircare system should be able to address, it should also use culturally appropriate skills to style the hair. Using culturally appropriate skills such as making dreadlocks or rishi knots and using tools such as hair picks may not only contribute to added physical comfort (e.g., by not pulling on the hair excessively), it may contribute to the robot system behaving more closely aligned to the user's expectations.

### 3.3 Cost

Even if the robot haircare system is functionally inclusive and robust, associated costs for the purchase and operation may in practice prohibit access to many marginalized communities and regions. Analogously, researchers have highlighted challenges faced by low- and middle-income countries in adopting robots for stroke rehabilitation [11]. Additionally, many state-of-the-art robotic healthcare and assistive technologies have largely been made available only to the wealthier socioeconomic groups even in high-income countries such as the United States [34].

Without the consideration of cost, haircare robot systems and technologies may work to widen the socioeconomic disparity in various areas of life such as elderly and disability care. Taking inspiration from related efforts in medical and rehabilitation robots [11, 16, 30], there should be an effort to develop robot haircare systems that are affordable, robust to different environments, locally repairable, and easily operable.

### 3.4 Risks and Concerns

Some researchers have recently raised concerns over the ethical risks associated with identity-based personalization of robot agents [37]. A primary concern raised by researchers is that explicitly identifying identities may work to inadvertently propagate problematic and prejudiced notions of race, gender, and other dimensions of identity.

For robot haircare, some degree of identity-related classification is required as the robot must be able to perceive and understand various physical properties of the hair and reason about the user's preferences. Such perceived properties may reflect the user's identity as proxy identifiers. For instance, certain ranges of hair thickness, straightness, and color may cumulatively be associated with individuals of a certain race [22]. As such, much of the considerations made in this section assume that robot haircare systems will at least implicitly reason about the user's identity. However, we could minimize the risk of harm by avoiding explicit consideration of the user's identity and taking into consideration the user's self-identified preferences for the desired style.

Robust preference communication between the human and the robot agents should be a component of an inclusive and useful robotic haircare system. In some HRI applications, however, complete compliance of the robotic agent to human commands may

result in problematic results [4]. For instance, particularly for hair-care, the developed robot system may further enable offensive human behaviors such as cultural appropriation of hairstyles [7] in the United States. Appropriation of hairstyles and other harmful or offensive behaviors should be explicitly considered in the development of a robotic haircare system that can recognize and appropriately refuse user requests that may do social harm or offend norms.

## 4 PLANNED STUDY

In order to design a hair ontology to define research directions for assistive robotic haircare, we aim to gather information from a variety of stakeholders in the system. We are interested in both experts in haircare as well as actual end-users of the system.

### 4.1 Data Collection

We aim to interview three types of participants: hair-care professionals, caretakers, and participants with limited mobility. These participants will be recruited from populations in the surrounding community through flyers, email lists, and word-of-mouth. Participants will engage in a 30-minute semi-structured online interviews.

For hair-care professionals and caretakers, the interview will focus on the different considerations needed for manipulating hair on people of varying identities along racial, ethnic, gender, and sexual orientation axes. This interviews will investigate what strategies a robot may need to take to work well with varying hair types. These participants will discuss to what extent different types of hair are similar and in what ways they differ. These participants may also speak about the various impacts of haircare beyond functional assistance, which will inform how an assistive haircare system should be designed.

For participants affected by limited mobility, the focus of the interview will revolve around how participants expect to interact with a system that provides assistance with haircare. We also aim to gather any reservations, concerns, or anticipated negative effects of using a system for assistive haircare. By interviewing the anticipated end-users we can develop an understanding for the ways the robots can maximally meet the needs of this specific population, incorporating any potential harms of the system directly into the design process.

We aim to recruit approximately 20 participants from each category of participant to interview, for a total of 60 participants. The recruitment will officially end when the study reaches theoretical saturation as defined by Saunders et al. [31]. Given the limited size of the dataset due to location constraints, we plan to augment the semi-structured interviews with data collected from videos posted online. This can allow us to incorporate a wider variety of identities that may not be recruited to partake in the semi-structured interviews.

### 4.2 Proposed Analysis

After interviewing the participants, we aim to analyze the findings through a iterative inductive thematic analysis of the interview transcripts and collected haircare videos. The procedure will follow the following steps, conducted across a research team consisting of researchers of various identities: (1) all interviews transcripts

and haircare videos will be coded with topics of discussion, (2) researchers will independently compile these codes into different themes, (3) researchers will meet as a team to discuss the themes that emerged, (4) concepts will be grouped into hierarchical themes, and (5) steps 2-4 will be iteratively repeated until the team reaches a consensus on what themes are important for assistive robotic haircare.

### 4.3 Mitigating Risks and Biases

In order to mitigate the risks associated with collecting data from vulnerable populations, we will take several considerations. First, we will submit the proposed protocol to an IRB to verify that that study follows ethical guidelines. Participants will be directly and clearly informed of what is expected of them and the overall procedure of the study.

To reduce biases in the data itself, the interview population will be sampled to include identities that span several intersecting axes. In addition, the interviews will be conducted with interviewers of varying identities. Ideally, interviewers and interviewees will have some shared experiences to establish and build rapport between the researcher and participant, as is common in ethnographic research [18]. Having established rapport with the interviewee can elicit more genuine responses to research questions and mitigate biases that may be introduced through demand characteristics, perceived authority, and other power dynamics.

To reduce biases in the analysis of the data, we will perform a thematic analysis with several researchers of varying identities. The identities of the analysts will be critically examined to determine how identities shape the outcomes of the analysis, and the reflections will be summarized in a positionality statement.

## 5 CONCLUSION AND FUTURE WORK

We outlined some of the practical and ethical considerations that should be made in the development of robot haircare systems. Primarily, we argue that we should not only consider the hair type of the user but also an expression of the user's preferred identities. Additionally, we outline various risks and concerns associated with the development of a robot haircare system and propose mitigation approaches to minimize potential harm. As an extension of this work, we plan to construct a robot haircare manipulation strategy taxonomy with the considerations outlined in this work.

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