

An African Perspective on Culturally Competent Social Robotics

Why Diversity, Equity, and Inclusion Matters in Human-Robot Interaction

By David Vernon 

Artificial intelligence (AI) and robotics are playing a central role in driving the Fourth Industrial Revolution in Africa, powering the digital transformation of African economies through technological innovation. However, successful innovation requires trust, acceptance, and widespread adoption. In turn, these depend on sociocultural factors. This is particularly true in the case of social robotics, where cultural competence is pivotal for adoption. We provide examples of culture-specific knowledge derived from diverse social and cultural norms in African countries and explain how this impacts social robots if their behavior is to be acceptable. We conclude by unwrapping the concepts of diversity, equity, and inclusion, and we explain how culturally competent social robotics can impact each of these three issues.

SOCIOCULTURAL FACTORS UNDERPIN THE FOURTH INDUSTRIAL REVOLUTION IN AFRICA

AI is having an increasingly positive impact in Africa in many sectors, such as energy, health care, agriculture, public services, and financial services. It has the potential to drive economic growth, development, and democratization, reducing poverty, improving education, supporting health-care delivery, increasing food production, improving the capacity of existing road infrastructure by increasing traffic flow, improving public services, and

improving the quality of life of people with disabilities. AI can empower workers at all skill levels to make them more competitive.

AI forms the foundation of the Fourth Industrial Revolution, Industry 4.0. Countries around the world have prepared AI strategies to ensure they are in the vanguard, leading the revolution. The scope of these strategies is extensive, embracing the research and development necessary to advance AI science and engineering, the strategies for promoting innovation, and the standards required for the ethical use of AI. While most of the effort to develop and exploit AI happens in developed countries, there is increasing awareness of its relevance to developing countries, with some countries, such as Rwanda, creating national AI strategies and hosting a World Economic Forum Center for the Fourth Industrial Revolution (C4IR). (South Africa also hosts a World Economic Forum C4IR.) Africa, a continent comprising 54 countries, launched a 10-year plan in 2022 for the digital transformation of its economies (the Digital Transformation Strategy for Africa, 2020–2030; see [11]).

The Fourth Industrial Revolution and digital transformation require innovation, something that is not as straightforward as it might seem. Rose [1] distinguishes among creativity, invention, and innovation. Creativity can lead to the invention of a novel idea or artifact, but innovation carries the creativity and inventions into wider use: the diffusion of that invention and its widespread adoption, leading to substantial social change in the practices

of a community of people. He captures this in an equation: “innovation = invention + exploitation + diffusion,” where the invention is commercially developed; exploited; and, significantly, adopted in a wider community of users.

Successful innovation depends on infrastructure. Rose [1] notes that “infrastructure is the unnoticed precondition for technology innovation.” There are two forms of infrastructure, the physical and the social. The physical infrastructure includes the availability of electrical power, communications networks, or Internet connectivity, something that is taken for granted in developed countries but that cannot always be assumed in developing countries. Of equal importance is social infrastructure, which includes the social conventions that govern people’s behavior and the practices they find acceptable and unacceptable. Social infrastructure heavily impacts whether or not an invention is adopted and becomes an innovation that can yield benefits for the local community. Social infrastructure includes trust and people’s sense of what is trustworthy.

Hoffman et al. [2] define trust as “the expectation that a service will be provided or a commitment will be fulfilled,” emphasizing the importance of expectation in their definition. Expectations are grounded in the sociocultural experience of those whose trust is required. The importance of the cultural context in building trust is emphasized by Lee and See [3]. They define culture as “a set of social norms and expectations that reflect shared educational and life experiences

associated with national differences or distinct cohorts of workers.” An awareness of these social norms and expectations—and the sociocultural background from which they arise—is crucial to the development of trust in and acceptance of any new technology, including AI-based products and services, such as social robots, and, by extension, to their diffusion and adoption.

Culture can be characterized in many ways. Hofstede identifies six dimensions in which an understanding of cultural issues should be addressed [4]. Others highlight the different ways that cultures perceive time and space, noting that concepts of time in the West and in Africa differ significantly [5]. These factors have a bearing on how technology, generally, and information technology powered by AI, in particular, can support an individual or a local community in Africa and whether or not that support, no matter how well intended, will be accepted, trusted, and adopted. Lack of trust can severely and negatively impact the adoption of these services and products, fatally undermining the achievement of the anticipated benefits [2]. Furthermore, AI and robotics bring their own special factors, e.g., explainability, transparency, and lack of bias, all of which have an influence on whether or not products and services that use AI will be trusted and adopted.

The consequence of this argument is that, if developing countries in Africa are to reap the rewards of adopting AI, innovation needs to be founded on the sociocultural factors that impact trust, which is essential for adoption and the realization of the benefits of the technological invention.

To summarize: socioeconomic development in Africa must be sensitive to people’s cultures for it to be successful. Concerning the role of AI, Virginia Dignum [6] drives this home when, in *Responsible AI in Africa*, she says, “Research and development of AI systems must be informed by diversity, in all of the meanings of diversity, and obviously including gender, cultural background and ethnicity.” While the overarching agenda of the inclusive digital transformation of Africa is

widely recognized to have the potential to have a positive disruptive influence on many aspects of the lives of African citizens, the transition from recognition of potential to realization of benefits is not a straightforward matter. The transition depends on turning technological invention into innovation, requiring widespread adoption. However, adoption, especially of AI, depends on trust, which, in turn, depends on social and cultural sensitivity.

We now pursue this argument in the context of social robotics.

CULTURALLY COMPETENT SOCIAL ROBOTICS

The need for AI technology to be culturally competent and capable of interacting effectively with humans is, perhaps, best exemplified by the field of social robotics, a field that is growing quickly. The global social robotics market was valued at US\$1.98 billion in 2020 and is expected to reach US\$11.24 billion by 2026, registering a compound annual growth rate of 34.34% during the period of 2021–2026 [12].

Social robots aim to serve people in a variety of ways and operate in everyday environments, often in open spaces, such as hospitals, exhibition centers, and airports, providing assistance to people, typically in the form of advice, guidance, or information. The people interacting with the robot have no special training, and they expect the robot to be able to interact with them on their terms, not the robot’s. There are two aspects to this expectation.

First, it means that social robots need to be able to interpret the intentions of the people with whom they are interacting. This is difficult to achieve because humans do not necessarily articulate their specific needs explicitly when they interact with social robots (or, indeed, with other humans). As Sciutti et al. [7] note, “the ability of the robot to anticipate human behavior requires a very deep knowledge of the motor and cognitive bases of human-human interaction.” Furthermore, humans use a variety of ways—spatial, nonverbal, and verbal—to communicate their needs, desires, beliefs, intentions, and emotions. These

are heavily influenced by social and cultural norms.

Second, and conversely, humans have expectations of the robot’s behavior, and they have a distinct preference for robots that exhibit legible and predictable behavior [7]. Since people make predictions based on what they are used to, robot behaviors must be tuned to the sociocultural context in which they are operating, and their spatial, nonverbal, and verbal communications must reflect the social and cultural norms of their interaction partners.

A culturally competent robot requires at least five elements: 1) cultural knowledge representation; 2) culturally sensitive planning and action execution; 3) culturally aware multimodal human–robot interaction; 4) culture-aware human emotion recognition; and 5) culture identity assessment, habits, and preferences [8] as well as intention recognition and some capacity for forming a theory of mind.

Ideally, culturally competent robotics combines top-down and bottom-up approaches based on the predetermined profiles of a cultural group and the cultural profiles derived from the behaviors of individuals, respectively.

Culture-specific knowledge, i.e., the knowledge of cultural and social norms, must be encapsulated in a knowledge ontology for use in a knowledge representation and reasoning system when selecting culturally sensitive robot behavior and recognizing culturally dependent human behavior.

In short, social robots must be culturally competent to be effective, and, therefore, social robotics must embrace cultural diversity if they are to be widely adopted.

DIVERSITY IN CULTURAL COMPETENCE

While there are studies on cultural differences in the acceptance of robots in the West and East, similar studies of the cultural factors that impact their acceptance in Africa have not been reported. (A survey by Lim et al. [9] briefly mentions Egypt, Tunisia, Libya, and Sudan, but only to contrast perceptions with the Gulf region when interacting with an

Arabic robot.) This highlights the need to identify culture-specific knowledge through ethnographic research.

The specific factors that underpin effective human-robot interaction include spatial interaction (proxemics, localization and navigation, socially appropriate positioning, initiation of interaction, and communication of intent), nonverbal interaction (gaze and eye movement, deictic, iconic, symbolic, beat gesture, mimicry and imitation, touch, posture and movement, and interaction rhythm and timing), and verbal interaction (speech, speech recognition, language understanding, and speech generation). These spatial, nonverbal, and verbal interaction factors must be adjusted to reflect the traits that would make social robots effective in Africa.

It is important to recognize that there are many different cultures in Africa, with many different norms for deictic, iconic, and symbolic manual gesturing as well as gestures involving eye gaze, head tilt, eyebrow movement, and body posture generally. Similarly, there are many different ways in which spoken language can express nuances of meaning by modulating amplitude and timbre.

Once the verbal and nonverbal social and cultural norms of human interaction that are prevalent in different countries in Africa have been identified, they can then be encapsulated in the behavioral traits of social robots so that these robots engage with African people in a manner that is consistent with their expectations of acceptable—respectful—social

interaction rather than using inappropriate or insensitive social behaviors and modes of interaction from the West or the East.

INTERACTION IN AFRICA

While a much more formal ethnographic study is required (a formal ethnographic study is currently underway in Rwanda [13]), Tables 1 and 2 present a sample of preliminary findings on the cultural factors that impact on the acceptance of social robots in Africa, the preferred behavioral traits that are considered appropriate for human-robot interaction in Africa, and design patterns for culturally sensitive social interaction in human-robot interaction, tuned to the preferences of African people. (This sample of 25 sociocultural

TABLE 1. A sample of African culture-specific knowledge.

| NUMBER | SOCIOCULTURAL NORM OR TRAIT |
|--------|---|
| 1 | All interactions should begin with a courteous greeting. |
| 2 | The younger interaction partner should enable a greeting to be initiated by an older person. |
| 3 | The younger interaction partner should bow when greeting an older person or when rendering a service. |
| 4 | One should not wave at someone from a distance; one should move toward them to greet them. |
| 5 | To show respect, one should bow slightly and lower the gaze when greeting someone older. |
| 6 | To show respect, one should raise both hands and lower the gaze a little when greeting. |
| 7 | One should suspend work or movements and pay attention when addressed. |
| 8 | One should use an open palm of the hand to point to people and objects. |
| 9 | One should not point an upward facing palm of the hand at someone. |
| 10 | One should not use the left hand to point to anything. |
| 11 | One should not use the left hand to hand something to someone. |
| 12 | To show respect, one should hand over and accept gifts with two hands and do so from the front, facing the recipient. |
| 13 | It is respectful to use local languages, and they should be used for verbal interaction when possible. |
| 14 | One should use formal titles when addressing someone. |
| 15 | One should engage in a preamble before getting to the point, as being too forward may be regarded as disrespectful. |
| 16 | One should not interrupt or talk over someone when they are speaking. |
| 17 | One should not talk loudly to an older person. |
| 18 | One should keep intermittent eye contact; lack of eye contact depicts disrespect, as it shows divided attention during the interaction. |
| 19 | One should not make persistent eye contact with an older person. |
| 20 | One should not make eye contact when being corrected. |
| 21 | To show respect, one should shake hands with the right hand and use the left arm to support the right forearm when doing so. |
| 22 | One should not walk far ahead of an older person, unless leading the person (in which case, one should walk slightly to the side). |
| 23 | One should not walk between two or more people who are conversing; it is considered rude to do so. |
| 24 | An appreciation of rhythmic sound and movement is valued. |
| 25 | Behaviors should focus on fostering social connections and relationships; they should not be purely functional. |

TABLE 2. A sample of Africa-centric design patterns for social robots (adapted from [10]).

| DESIGN PATTERN | CULTURALLY COMPETENT BEHAVIOR |
|--|--|
| Initial introduction | The robot should acknowledge the presence of the person. The robot should initiate an interaction with a slight bow. The robot should greet first and should use a formal greeting. The robot should respect personal and intimate distances during interaction. |
| Reciprocal turn taking | The robot should respectfully give the initial turn to the human interaction partner. The robot should give priority to older people; it should not interrupt, and it should let the other person finish their turn. |
| Didactic communication | Pointing a hand directly at someone is disrespectful. For deictic gestures, the robot should use its left hand. The robot should gesture with an open palm rather than pointing a finger. |
| Personal interests and history | The robot should avoid trying to share personal history since it will be perceived to be inauthentic. The robot should focus on and highlight its functional usefulness. |
| In motion together | The robot should explicitly say, “Please come along,” to remove any ambiguity of intention. The robot should not walk too far ahead when showing the way. |
| Recovering from mistakes | The robot should apologize profusely. The robot should slightly bow when introducing itself and after it makes a mistake. |
| Physical intimacy | Personal space should be entered only with prior consent. The robot should not pass in between two people who are interacting. |
| Claiming unfair treatment or wrongful harm | To enhance the perception that the robot is being respectful, the robot should not be aggressive by claiming unfair treatment. |

norms or traits is based on a survey of 23 people from eight countries in Africa.) We base the design patterns on the eight design patterns for sociality in human–robot interaction proposed by Kahn et al. [10] and recognize that they need to be augmented with specific Africa-centric design patterns.

UNPACKING DIVERSITY, EQUITY, AND INCLUSION

We conclude by considering the sociological implications of a discipline of culturally competent social robotics that fully embraces diversity, equity, and inclusion. To do this, we need to unpack what is meant by these three terms.

Diversity concerns the many different dimensions in which people differ. Gender, sexual orientation, race, culture, socioeconomic status, traditions, education, age, religious and spiritual beliefs, nationality, ethnicity, experience, and physical ability: these are just some of the facets that characterize diversity. Diversity creates opportunities for greater mutual understanding of the individual contribution that a person of each background can make. It does this by breaking down barriers—typically manifested as preconceptions and bias—and exposing what is special and positive in each individual. In a sense, diversity is a means to an end: a way of tapping into everyone’s

potential and using that potential to empower everyone else through mutual respect.

Realizing this makes it easier to understand the concept of equity. In contrast to equality, equity is less concerned with treating everyone equally and more about doing what is necessary to allow each person to make their special individual contribution and to participate just as much as everyone else. Equality is passive; equity is active. It is the act of empowering, the process that leverages the potential latent in diversity. Without equity, the power of diversity cannot be realized.

By themselves, diversity and equity create the necessary conditions for belonging, but they cannot guarantee that these conditions will lead to a positive interaction between each person in that environment. This is what inclusion means: that each person feels that they belong in that environment and that their place in that environment is valued. It is not enough that they are present and empowered but that they are visibly, openly, and transparently valued by everyone else. Naturally, this is a reciprocal process, and, therefore, it can only be achieved by mutual respect for the perspectives of others. This is the essence of empathy. It necessitates that each individual actively adopts the per-

spective of others and sees the value in it, irrespective of whether or not she or he agrees with it, at that moment in time. Eventually, exposure to these perspectives brings about a greater and deeper understanding as well as a more harmonious, effective, and fulfilling way of interacting with one another. Inclusion is the psychological prerequisite of mutual empathy that allows diversity and equity to function effectively in creating a better, richer, more enlightened mode of interaction. This is neatly summarized by the poet George Eliot (the pen name of Mary Ann Evans): “The highest form of knowledge is empathy, for it requires us to suspend our ego and live in another’s world.”

This is the essence of an unbiased theory of mind, when someone—or some social robot—takes a perspective on the needs, desires, beliefs, intentions, and emotions of others, understanding the manner in which these are modulated by sociocultural predispositions and preferences and acting accordingly in an empathetic manner.

The development of culturally competent social robots that can achieve this level of understanding of their interaction partners would not only facilitate effective human–robot interaction by

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2024

12–14 DECEMBER

2024 International Conference on Flexible Electronics and Systems (ICFES). Hong Kong, China. <http://www.ieee-icfes.org/>

17–18 DECEMBER

2024 Third International Conference on Automation, Robotics, and Computer Engineering (ICARCE). Virtual. <https://www.icarce.com/>

19–21 DECEMBER

2024 Fourth International Conference on Robotics, Automation and Artificial Intelligence (RAAI). Singapore, Singapore. <https://www.raai.net/>

27–29 DECEMBER

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2024

15–17 JANUARY

2025 Ninth International Conference on Mechanical Engineering and Robotics Research (ICMERR). Barcelona, Spain. <https://www.icmerr.com/>

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21–24 JANUARY

2025 IEEE/SICE International Symposium on System Integration (SII). Munich, Germany. <https://sice-si.org/SII2025/>

12–14 FEBRUARY

2025 11th International Conference on Automation, Robotics, and Applications (ICARA). Zagreb, Croatia. <https://www.icara.us/>

24–26 FEBRUARY

2025 11th International Conference on Mechatronics and Robotics Engineering (ICMRE). Lille, France. <https://www.icmre.org/>

3–6 MARCH

2025 20th ACM/IEEE International Conference on Human-Robot Interaction (HRI). Melbourne, Australia. <https://humanrobotinteraction.org/2025/>

14–16 MARCH

2025 IEEE First International Conference on Materials, Robotics & Automation, Computer, and Control (ICMRACC). Kannur, India. <https://vjec.ac.in/icmracc/>



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leveraging cultural and social norms, but it would also contribute to the empowerment of the individuals with whom the social robots are interacting by recognizing and valuing the importance of those individuals' cultural heritage. This, surely, is one of the primary goals of social robotics and the purpose of a science of human–robot interaction that fully embraces diversity, equity, and inclusion.

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