Culturally competent social robots target inclusion in Africa

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Embedding culturally sensitive body, hand, and facial gestures in social robots will make them more acceptable in Africa.

Africa has embraced artificial intelligence (AI) with open arms, recognizing its potential to drive economic growth, accelerate development, reduce poverty, deliver education, support health care, increase food production, and streamline public services (*1*, *2*). Although AI can certainly drive technological invention, creating new ways of doing things, these inventions have to be widely adopted by people if we are to realize the social and economic benefits. However, adoption depends on social infrastructure: the conventions that govern people's behavior, the practices they find acceptable and unacceptable, and what they deem to be trustworthy (*3*). Cultural competence, i.e., an awareness of social norms and cultural expectations, is a key element in fostering this acceptance.

The need for technology to be culturally competent is perhaps best exemplified by social robotics, a field that is growing quickly: The global social robotics market was valued at $1.98 billion in 2020 and is projected to reach $11.24 billion by 2026 (*4*). Social robots serve people in a variety of ways, operating in everyday environments, and providing assistance to people, typically in the form of advice, guidance, or information. The people who interact with these robots expect the robot to be able to interact with them on their terms, not the robot's. This means that the robot must have culture-specific knowledge and the ability to deploy that knowledge effectively. To avoid stereotypical interaction, this knowledge should include cultural profiles learned from the behaviors of individuals as well as general cultural characteristics based on the population as a whole (*5*); see Fig. 1A.

Ethnographic research at Carnegie Mellon University Africa, in collaboration with University of the Witwatersrand, is helping to uncover the factors that underpin effective human-robot interaction in Africa, specifically in Rwanda and South Africa. There are many factors to consider when embracing nonverbal, verbal, and spatial interaction. Nonverbal interaction, especially, requires knowledge of cultural norms, such as acceptable ways to direct your gaze and make eye contact, and acceptable forms of body, hand, and face gestures. For example, in Rwanda, when shaking hands with someone, the right arm should be supported by the left to show respect. A slight bow is appropriate when initiating an interaction with an elder, and making too much eye contact is usually not acceptable. A slight raise of one's eyebrows or head is considered a polite way of acknowledging someone's presence. The left hand should never be used to point, and pointing gestures should use an open, upturned palm, not a finger.

Verbal interaction involves more than just the spoken message: The volume and timbre must be modulated to respect cultural preferences. For example, in Africa, respect is shown to elders by speaking softly but audibly. Spatial interaction requires knowledge of proxemics: how to position yourself relative to others. For example, it is considered rude to walk between people who are talking to one another.

These are just a few of the many ways that social robots should interact if they are to be culturally sensitive, enabling them to engage with African people in a manner that is consistent with their expectations and avoiding the use of inappropriate social behaviors imported from elsewhere.

At Carnegie Mellon University Africa and University of the Witwatersrand, these behaviors are being encapsulated in a software system that controls a Pepper social robot [see Fig. 1B] (*6*) that uses adaptable software primitives to generate culturally sensitive human-robot interaction (*7*). The system's six components are responsible for the detection of people, faces, eyes, gaze direction, hands, and voices. They are also responsible for classifying events in the robot's environment. They produce minor movements that give the impression that the robot is paying attention, visually scanning the surroundings for people. When interacting, they interpret a scenario script and generate culturally sensitive interaction behaviors on the basis of an African culture ontology and knowledge base.

Human-robot interaction in the African context has motivated researchers to revisit the uncanny valley challenge in robotics—avoiding a negative emotional response toward robots that bear a close, but not sufficiently close, resemblance to humans, especially when the robot alters its facial expressions—and how different cultures may have different expectations of what makes a robot look and behave "human." In the AI-robotics course titled *Humanoid Robotic and Cognition* at CMU-Africa, students are taught to build a replica of the open-source robot Eva (Fig. 1C) (*8*, *9*) to learn the technical challenges of synchronizing lip and facial gestures with audio output.

According to students who have studied AI and robotics at CMU-Africa, this research is impactful in Africa in several ways. First, it provides Africans engaged in the research with the opportunity to develop their understanding of the technology of human-robot interaction while also gaining a deeper knowledge of Africa's many cultures. Second, it serves as a stepping stone toward acceptance and adoption of social robotics in Africa, where it still faces resistance because most robots have been tailored for Western cultures and Africans do not understand or relate to how these robots work. Adapting the features and characteristics of these robots and their interactions to align with African cultural norms makes them more relatable and more likely to be accepted and adopted for use in Africa. Third, the use of culturally sensitive robots in the hospitality

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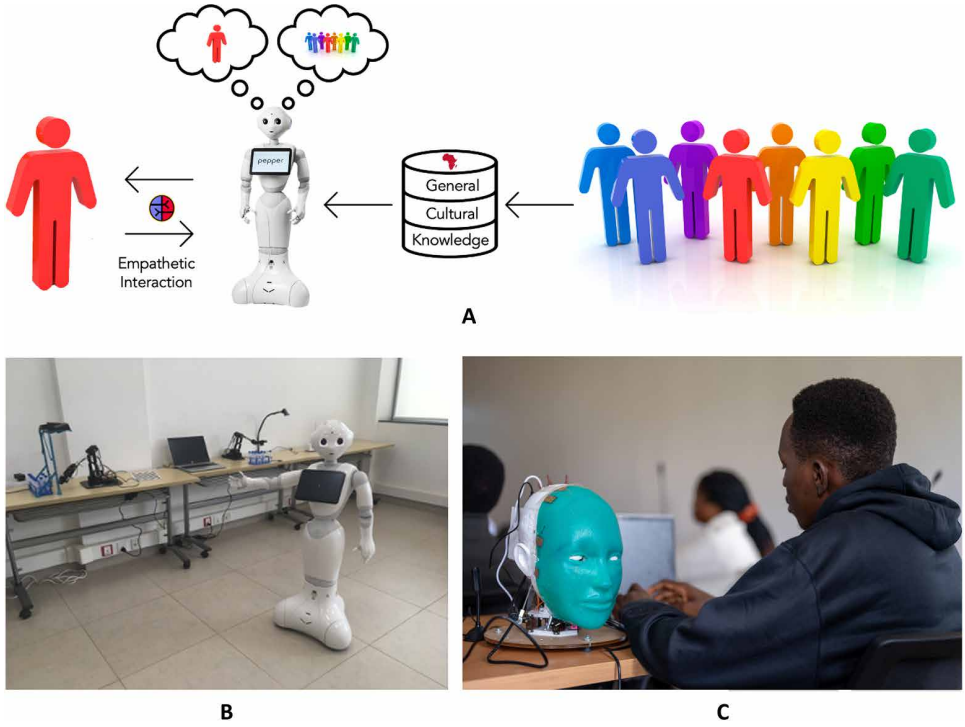

Fig. 1. Cultural knowledge underpins respectful interaction. (**A**) The concept of a culturally competent social robot that can use general cultural knowledge and adapt to avoid stereotyped behavior [based on (*5*); empathy symbol from www.EmpathySymbol.com]. (**B**) The Pepper robot displaying a hand gesture. (**C**) A student programming the Eva robotic head to display facial gestures.

industry can greatly aid in presenting African culture to tourists, especially when conventional social robots may not adequately represent African heritage. These robots can be programmed to provide culturally relevant information about African traditions, history, and customs to travelers from around the world. They can introduce visitors to the local language while reflecting and respecting local cultural norms and values. This not only enhances the tourist experience but also promotes a deeper understanding and appreciation of African culture among international travelers. These robots can serve as cultural ambassadors, bridging the gap between technology and tradition, and making African culture more accessible to a global audience.

Last, this research showcases how modern advances such as AI can work cooperatively with local traditions to improve life while respecting the culture's core values. Robots that align with cultural sensibilities provide a template for how technology can be harnessed progressively. This foundation of trust and mutual understanding paves the way for African communities to confidently adopt new tools that uphold their values. The insights gained from imbuing robots with cultural knowledge can guide societies in integrating not just robots but potentially transformative technologies like renewable energy, telemedicine, and modern agriculture. Culturally competent robots thus facilitate the adoption of innovation across sectors in a way that empowers communities to direct change on their own terms.

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