Achieving Kinetic Anthropomorphism in Robotic Precision Tasks

Rosanna Coccaro
rcoccaro@unisa.it
University of Salerno
Fisciano, Italy

Enrico Ferrentino
eferrentino@unisa.it
University of Salerno
Fisciano, Italy

Antonio Parziale
anparziale@unisa.it
University of Salerno
Fisciano, Italy

Angelo Marcelli
amarcelli@unisa.it
University of Salerno
Fisciano, Italy

Pasquale Chiacchio
pchiacchio@unisa.it
University of Salerno
Fisciano, Italy

ABSTRACT

In this position paper we address the issue of acceptance in human-robot interaction, a topic often associated with anthropomorphism. The literature around this concept lacks of a discussion around the kinetic aspect of anthropomorphism, especially in applications where machine accuracy is required. We briefly summarize the results we achieved and outline some research directions promised to impact human-robot collaboration in sectors like manufacturing and medicine.

KEYWORDS

Human-Robot Interaction, Kinetic Anthropomorphism, Robot Acceptance

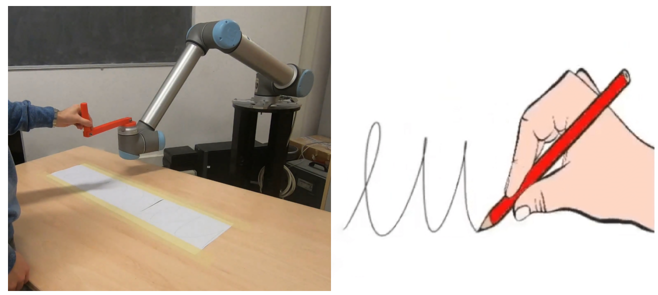
ACM Reference Format:
Rosanna Coccaro, Enrico Ferrentino, Antonio Parziale, Angelo Marcelli, and Pasquale Chiacchio. 2024. Achieving Kinetic Anthropomorphism in Robotic Precision Tasks. In *Adjunct Proceedings of the 32nd ACM Conference on User Modeling, Adaptation and Personalization (UMAP Adjunct '24), July 01–04, 2024, Cagliari, Italy*. ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3631700.3664891

1 WHAT IS KINETIC ANTHROPOMORPHISM?

Acceptance in Human-Robot Interaction (HRI) is a largely debated subject and often associated with anthropomorphism: we are likely to accept robots if they resemble us. We can coexist with them, merely sharing our workspace, as is the case of warehouses and household settings, or we can physically interact and collaborate, exchanging forces, as in several industrial and medical applications. In the former cases, we look for anthropomorphic features in the robot's physical appearance (e.g. humanoids) and cognitive abilities, such as perception and decision making (e.g. ChatGPT) [4]. We perceive such characteristics through visual and auditive cues. Otherwise, when physical interaction (pHRI) is established, we also rely on our somatosensory system, which is actively engaged to "feel" the robot's movement and allows us to "judge" whether we recognize it as familiar, thus comfortable. We refer to this movement-centered aspect of human-robot similarity as *kinetic anthropomorphism*. Whether kinetic anthropomorphism plays a predominant role even when pHRI is missing is an open question.

UMAP Adjunct '24, July 01–04, 2024, Cagliari, Italy

ACM ISBN 979-8-4007-0466-6/24/07
https://doi.org/10.1145/3631700.3664891



(a) (b)

Figure 1: (a) Physical interaction experiment setup, (b) observation experiment setup.

2 ARE TRADITIONAL APPROACHES TO KINETIC ANTHROPOMORPHISM SATISFACTORY?

To achieve anthropomorphism, the design of collaborative robots is bioinspired, and, in view of kinetic anthropomorphism, this is the case of motion and interaction control algorithms, too. Learning from demonstrations [2] and control through motor primitives [3] are two popular approaches. They target to imitate the velocity profile of human reaching movements, responding to a combination of smooth unimodal basis functions (e.g. a time superimposition of log-normal velocity profiles [6]). Is this enough? The short answer is no. What are we missing? The industrial and medical sectors are plentiful of applications that want to combine the cognitive abilities of humans (for e.g., product customization) with quality-safeguarding machine accuracy. Traditional programming approaches targeting kinetic anthropomorphism, however, do not account for path preservation. Hence, the challenge is preserving robot accuracy without loss of kinetic anthropomorphism.

3 WHERE DO WE STAND?

Our idea is to decouple, in a trajectory, the geometrical path from its time law [1]. We preserve accuracy by fixing the former, and achieve kinetic anthropomorphism by working on the latter. The approach combines phase plane analysis, i.e. the analysis of the tangential velocity on the path, with the theory of motor primitives, in a way that arbitrary time laws (including human-like ones) can be assigned to the same geometric path. In a pHRI experiment involving students from our institution (Fig. 1a), we asked to compare, by only relying on their somatosensory system, robotic movements on the same path showcasing different levels of similarity to the human movement. Set that the movements in the comparison were sufficiently different in terms of kinetic anthropomorphism, the students were able to discern them and to recognize the most human-like as the most comfortable one. Interestingly, when comparing replicas of human-recorded movements with human-like artificial profiles, no clear separation was possible. This provides more than an indication that every movement can be made human-like, regardless of the geometric path to be tracked. What about non-contact cases? In a previous experiment (Fig. 1b) [5], we asked participants to compare human-recorded and artificial movements of a hand-with-pen avatar writing on a canvas and conclude on which, in the pair, looked more human-like. Notably, in this setup, humans were not able to reliably distinguish between human and artificial movements. What do these results suggest? It is possible that visual cues are not enough to assess the degree of kinetic anthropomorphism in a movement, or the hand-with-pen avatar (or equivalent surrogates used in other experiments) cannot reach a sufficient level of aesthetic anthropomorphism for a human to self-identify with it. Perhaps, in the absence of a somatosensory feedback, if the robot were a humanoid, humans would rely on additional clues other than the mere hand movement, such as joint ranges and shoulder-elbow-wrist coordination.

4 WHAT NEXT?

We believe that future research should concentrate on robot programming approaches maximizing kinetic anthropomorphism, without sacrificing robot accuracy. On the other hand, solving the kinetic anthropomorphism in non-contact cases is harder and requires further investigation into the analysis of robotic systems with a higher degree of aesthetic and kinematic anthropomorphism.

REFERENCES

[1] Rosanna Coccaro, Enrico Ferrentino, Antonio Parziale, Angelo Marcelli, and Pasquale Chiacchio. 2024. A New Human-Likeness and Comfort Index for Robot Movements Along Prescribed Paths. (Jan. 2024). http://dx.doi.org/10.36227/techrxiv.170654612.26940673/v1

[2] Chang He, Xiao-Wei Xu, Xiong-Fei Zheng, Cai-Hua Xiong, Quan-Lin Li, Wen-Bin Chen, and Bai-Yang Sun. 2022. Anthropomorphic Reaching Movement Generating Method for Human-Like Upper Limb Robot. *IEEE Transactions on Cybernetics* 52, 12 (Dec. 2022), 13225–13236.

[3] Neville Hogan and Dagmar Sternad. 2012. Dynamic primitives of motor behavior. *Biol Cybern* 106, 11-12 (Nov. 2012), 727–739.

[4] Rae Yule Kim. 2024. Anthropomorphism and Human-Robot Interaction. *Commun. ACM* 67 (2024), 80–85.

[5] Giovanni Mignone, Antonio Parziale, Enrico Ferrentino, Angelo Marcelli, and Pasquale Chiacchio. 2023. Observation vs. Interaction in the Recognition of Human-like Movements. *Frontiers in Robotics and AI* 10 (2023).

[6] Réjean Plamondon. 2020. The Lognormality Principle: A Personalized Survey. In *The Lognormality Principle and Its Applications in E-Security, e-Learning and e-Health*. Series in Machine Perception and Artificial Intelligence, Vol. Volume 88. WORLD SCIENTIFIC, 1–39.