Human-Like Robotic Touch: A User Study

Can a robot deliver affective touch?

Yucheng Tang[1,2], Tara Chand[3,4], Ilshat Mamaev[1], Björn Hein[2], Ilona Croy[3]

[1] *Proximity Robotics & Automation GmbH*

[2] *Karlsruhe University of Applied Sciences*

[3] *Friedrich Schiller University Jena* [4] *O.P. Jindal Global University*

Introduction

- Affective touch is essential for emotional bonding, stress reduction, and overall human well-being. Soft brush stroking activates low-threshold unmyelinated mechanoreceptors (C-tactile fibers) most vigorously at intermediate velocities (1-10 cm/s).
- Physical touch significantly aids motor recovery, sensory stimulation, and emotional health in rehabilitation contexts. However, providing consistent, human-like therapeutic touch remains challenging in clinical practice. Previous robotic touch studies often lacked human-like variability or direct comparisons between robotic and human-delivered affective touch.
- We investigate whether robots can replicate human-like affective touch sensations using dynamic movement primitives (DMPs), focusing on both spatial (trajectory) and temporal (velocity) factors, and assess participants' ability to distinguish between human and robot touch.

Methods

Replicate human-like affective touch with a robot using only temporal (velocity) and spatial (trajectory) features.

Touch Delivery: Both human and robot used the same brush interface

Trajectory Generation:

- Human strokes recorded using interactive mode.
- Reproduced using Cartesian DMPs.
- Start/end forearm points sampled for adaptation to individual geometry.

Trajectory Generation (Predictability):

- Linear (High): 2 waypoints
- Curved (Medium): 3 waypoints
- S-Shaped (Low): 4 waypoints

Velocity Conditions:

- 0.3 cm/s (slow)
- 3.0 cm/s (target CT-optimal speed)

Conclusion

This study demonstrated that robots can deliver affective touch that is perceived as pleasant when mimicking key temporal (velocity) and spatial (trajectory) features of human stroking.

- **Pleasant touch is velocity dependent**: Robotic touch delivered at 3 cm/s can replicate the pleasantness of human touch, but not at 0.3 cm/s.
- **Trajectory has limited influence**: The human-likeness of robotic touch is not determined by spatial trajectory, suggesting that temporal features (speed) are more critical.
- **Turing test for touch reveals limitations**: Despite pleasantness, most participants correctly identified robot touch ($\sim$ 76%), indicating that spatial and temporal features alone are not sufficient to fully mimic human touch

Future systems should integrate force, pressure, and dynamic modulation to better replicate human touch—and ultimately improve performance in Turing-like evaluations of tactile social interaction.

Hardware and Experiment Setup

Franka Emika Panda:
7 degrees of freedom (DoF), 3kg payload.

Touch Interface:
Brush with ATI Mini40 force-torque sensor and ArUco marker.

Camera:
FRAMOS D400e RGB-D camera for capturing trajectory data.

Curtain Setup:
To prevent visual identification of the stroking agent.

Cushion and Forearm Slope:
Forearm rested on a cushion at a slight incline for optimal contact.

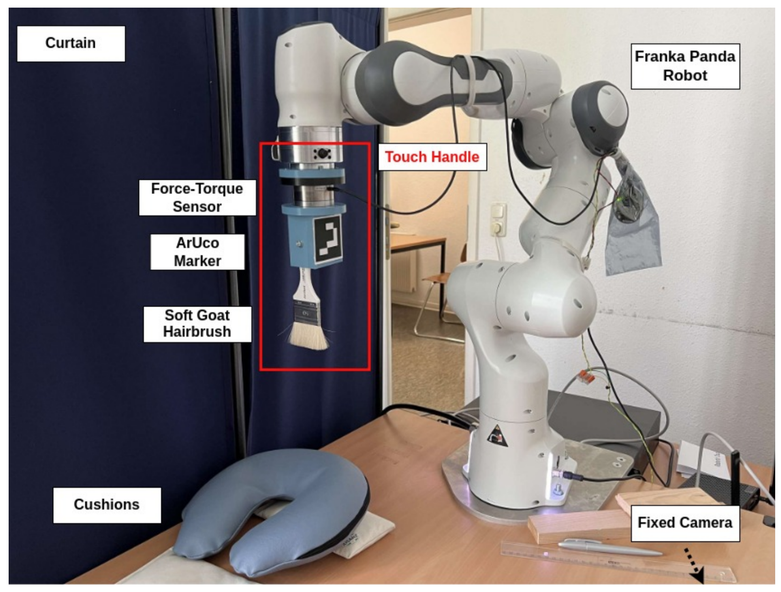


Figure 1: Experimental setup: robot with brush, force sensor, and camera.

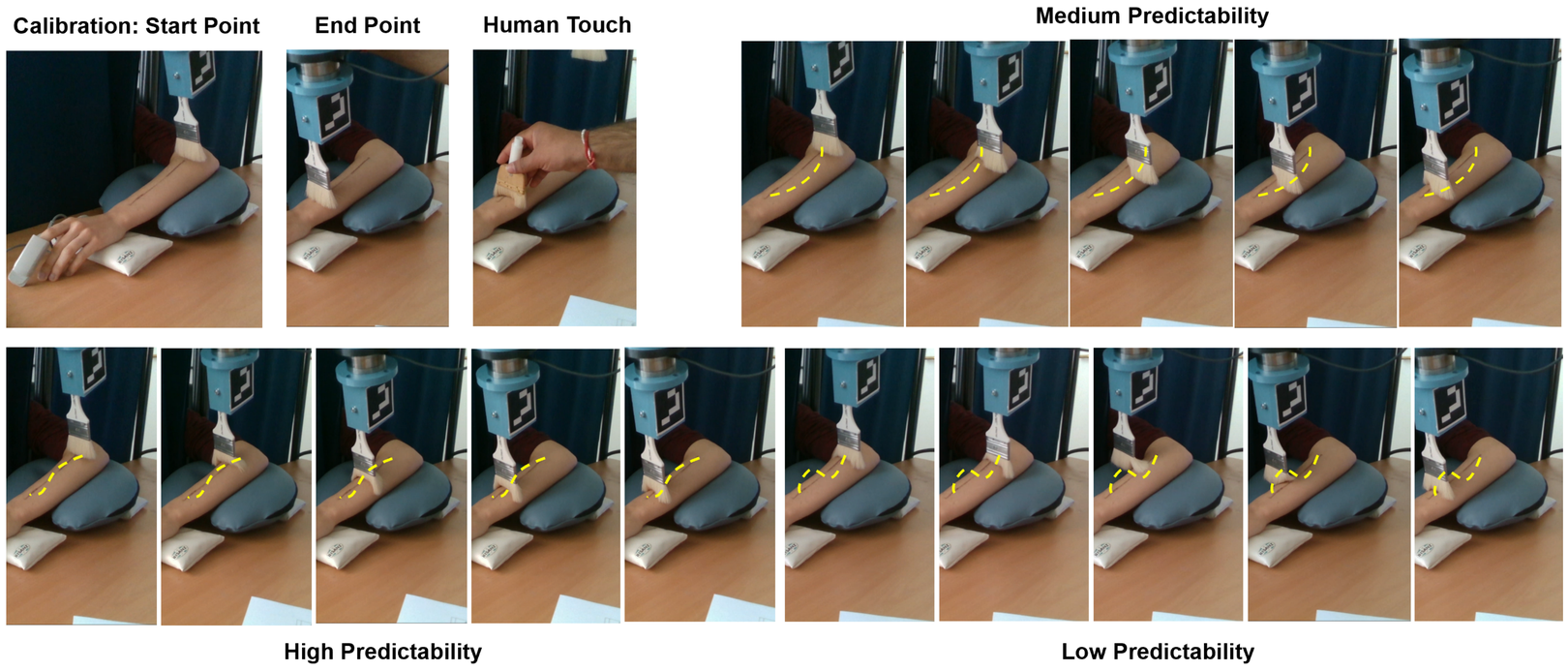


Figure 2: Affective robotic touch experiment setup

Experiment Design and Results

Participants: 34 female students (final N=28 after removing error trials).

Design: Each participant received 16 strokes (8 conditions $\times$ 2 repetitions) in a randomized order:

- **3 Human strokes:** 0.3 cm/s (linear), 3 cm/s (linear), 3 cm/s (nonlinear)
- **5 Robot strokes:** Linear (0.3 & 3 cm/s), Nonlinear (3 cm/s with high/medium/low predictability)

Assessment: Pleasantness, Intensity, Human-likeness, Human or Robot?

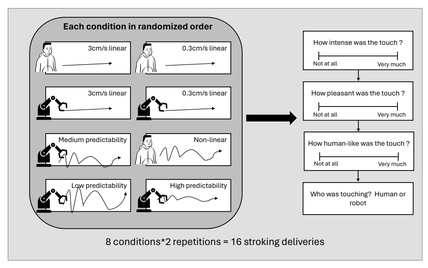


Figure 3: Experimental design

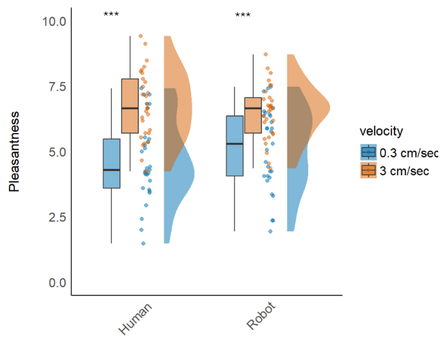


Figure 4: Pleasantness ratings: 3 cm/s strokes were rated significantly more pleasant than 0.3 cm/s, independent of agent.

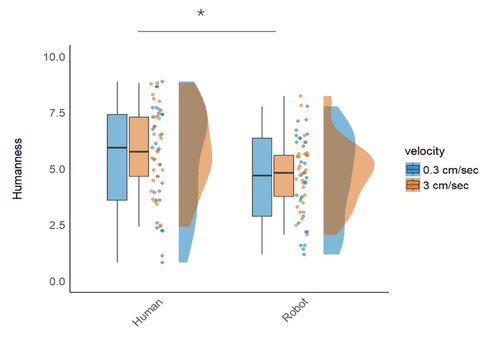


Figure 5: Humanness ratings: Human strokes were rated more "human-like" than robot strokes ($p < .05$).

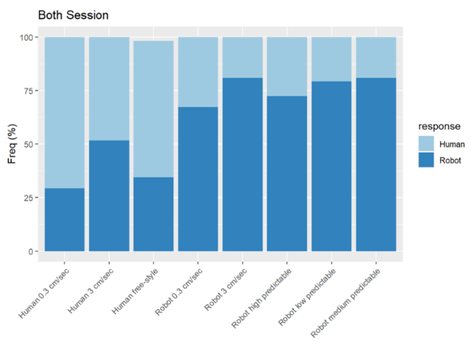


Figure 6: The percentage of the touch recognition delivered by agents.