Human-Centered Robotic Sock Dressing: Care Interaction Insights from a Public Demonstration at Expo 2025 Osaka

Waseda University · MOONSHOT RESEARCH & DEVELOPMENT PROGRAM · AIREC

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Why Dressing Assistance Matters

☐ **Dressing Support for Independence**
➢ Dressing is a fundamental activity for independent daily living.
➢ Difficulty in dressing limits mobility and social participation.

☐ **Challenges for Robotic Dressing**
➢ Handling highly deformable soft garments
➢ Close and safe human-robot physical interaction

System Overview and Performance

☐ System Overview
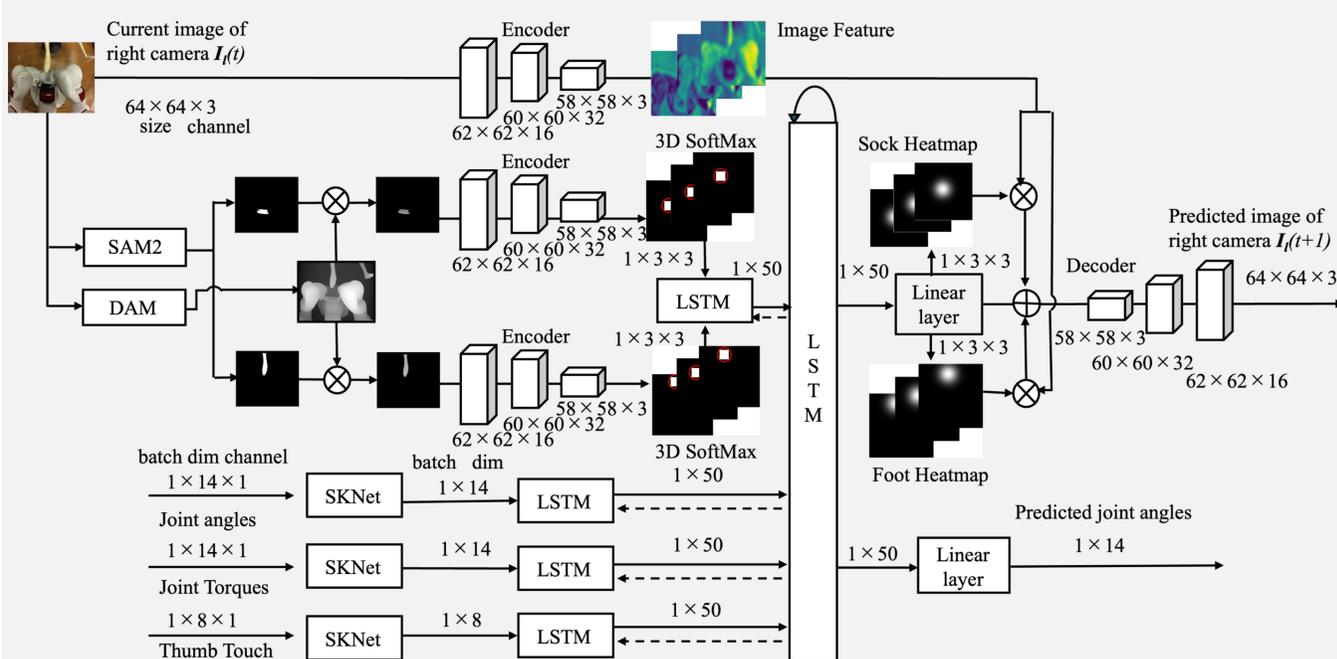
☐ Key Components
➢ Multimodal Sensing
➢ Semantic depth representation
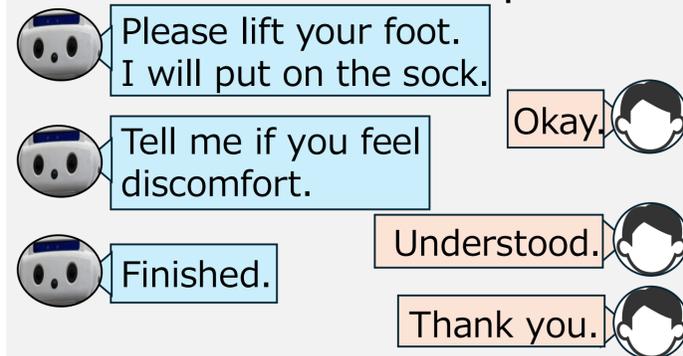➢ LSTM for adaptive force
☐ Training
➢ Mannequin → Human Eval

☐ Success Rate across foot size

Size of Foot	ACT	DP	Ours
23-24 cm	14/30	N/A	26/30
24-25 cm	14/30	N/A	28/30
25-26 cm	5/30	N/A	21/30
26-27 cm	0/10	N/A	4/10

What We learned from Osaka Expo 2025

☐ Human perception changed evaluation
➢ Slightly rigid motions appeared uncomfortable
➢ Psychological comfort dominated perceived safety
☐ Real-world interaction complexity
➢ Environmental voices caused context-mismatched
☐ System limitation revealed
➢ Limited adaptability and generalization (sock caught at toe/heel)

☐ Conversation example

Robot: Please lift your foot. I will put on the sock.
Human: Okay.
Robot: Tell me if you feel discomfort.
Human: Understood.
Robot: Finished.
Human: Thank you.

Open Questions in Care Robotics

☐ Autonomy
➢ Over-Assistance
➢ User control
➢ Adjustable speed/force

☐ Failure and Ethics
➢ Physical Harm Risk
➢ Trust Loss
➢ Ethical Responsibility

☐ Caregiver and Deployment
➢ Role Shift in caregiving
➢ Supervision workload
➢ Real-World Use

Conclusion: We proposed a multimodal imitation learning approach for close-fitting dressing assistance, integrating visual, proprioceptive, and tactile sensing with semantic representations to improve robustness across user variations. Beyond technical performance, assistive robotics must be evaluated by safety, comfort, and trust, not only task success. Even small failures (e.g., discomfort or misalignment) can have large consequences in intimate care tasks. This highlights the need for adaptive and human-centered design. Future work will focus on adaptive replanning to handle unexpected situations during real-world interaction, enabling long-term human–robot collaboration.