AIREC: Use Cases of AI-driven Robot for Embracement and Nursing Caring Tasks

Tamon Miyake
Waseda University
Tokyo, Japan

Yushi Wang
Waseda University
Tokyo, Japan

Tetsuya Ogata
Waseda University
Tokyo, Japan

Shigeki Sugano
Waseda University
Tokyo, Japan

***Abstract*—As part of the Moonshot Goal 3 project, we aim to develop AI-powered partner robots for domestic environments. In this paper, we present the future of AI-driven robots that operate physical nursing care. We experimented with AI-driven arm-motion generation for physical training, transfer assistance, and dress assistance. Looking ahead, we plan the further development of a deep-learning model capable of more various nursing care tasks with whole-body manipulation in more complex situations.**

***Index Terms*—Physical nursing care, Versatile robot, Imitation learning.**

I. INTRODUCTION

A multifunctional robot designed for domestic environments is gaining significant attention. Unlike industrial robots working in manufacturing, domestic robots must coexist with humans, prioritizing safety, human interaction, and autonomous handling of various objects. Research has explored integrating multimodal components to enhance human-robot collaboration in home settings. In particular, nursing care is important in aging societies.

Further advancements and continuous integration of embodied intelligence remain necessary. As part of the Moonshot Goal 3 project [1], our objective is to develop AI-powered partner robots that embody human sensibilities and ethical considerations, contributing to enriched lifestyles. In this paper, we present the future of AI-driven domestic robots by summarizing our previous works and the current progress of autonomous assistance for care patients by a humanoid.

II. PREVIOUS STUDIES

Some robotic arms are specifically designed to apply interaction forces to a target, particularly for caregiving tasks. A rule-based assistive system working alongside caregivers has been shown to reduce their workload in repositioning tasks [2], [3]. RIBA, a robot equipped with human-like arms for physically demanding tasks, successfully lifted a person from a bed and transferred them to a wheelchair [4]. Similarly, RoNa demonstrated the capability to lift a 227 kg patient [5].

To enhance human comfort, studies have evaluated interface pressure and patient positioning during lifting to determine optimal interaction points and applied forces [6], [7]. However, these conventional systems still lack autonomous motion planning capabilities. As a result, caregivers must manually adjust the robots' movement positions, directions, and speeds according to each situation.

Autonomous manipulation plays an essential role in executing daily caregiving tasks. A skeleton recognition system has been developed to autonomously plan to reach trajectories for touching a shoulder [8]. Dressing assistive robots [9]–[13] have successfully performed autonomous arm trajectory control around the human body. Moreover, integrating these systems with language models could enable communication-based behavior adjustments [11], [14]. Although dressing-assistance robots have addressed occlusion and variability challenges using multimodal information and DNN models, they primarily interact with clothing. These previous works did not engage in direct physical contact with the care recipient.

III. SYSTEM

Dry-AIREC (AI-driven Robot for Embrace and Care) is a versatile robot designed to learn and execute a wide range of complex, high-difficulty tasks. Its objectives include customer assistance, household chores such as cooking, laundry, and cleaning, long-term care tasks like patient transfer, bathing, and feeding, as well as medical support. We applied the Dry-AIREC system for the feasibility exploration of physical nursing caring.

The Dry-AIREC can modify the impedance parameters of its arm and waist joints during movement. The control modes—position, force, and impedance control—can be flexibly adjusted based on working conditions and task requirements. Activating compliance control mode enables the robot arm to effectively handle local disturbances, perform intricate manipulations, and interact safely with humans. The head joint is controlled using position-based control, while the mobility base operates with velocity-based control. Additionally, integrating text-to-speech, speech-to-text, and large language models enables the Dry-AIREC to communicate with humans effectively.

We experimented with AI-based arm-motion generation for physical training, transferring, and dressing assistance. The AI algorithms we relied on are the large language model (GPT-3.5, OpenAI) or deep predictive learning model "EIPL" [15] which adopts a motion learning approach to minimize real-world prediction errors. In repositioning and dressing tasks, we applied the proprioceptive attention mechanism based on EIPL [16]. To train the policy of the caring motion, direct teaching

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Fig. 1. A scene of the robot conducting the range of motion training

Fig. 2. A scene of the robot conducting the repositioning caring

was performed by manually guiding Dry-AIREC's arm with approximately 10 times for 10 minutes in each motion.

IV. Results and Discussion

First, the Dry-AIREC conducted a range-of-motion training for an arm of humans. Fig. 1 shows a scene of performing the range-of-motion training [14]. The Dry-AIREC can recognize the human body segment from a proximity distance, touch both a shoulder and a hand, and move a whole arm. The large language model facilitates parameter adjustment of arm velocity and touch strength corresponding to human requests.

Next, the Dry-AIREC conducted the transfer assistance. In particular, the repositioning tasks are challenging because the touching point is occluded, and high-precise touching is required. Fig. 2 shows a scene of repositioning caring based on deep predictive learning. Both reaching to the back of a mannequin without unnecessary contact to an unexpected point and assisting the sitting motion with a force application to the back were successfully performed [16].

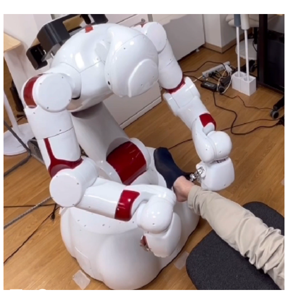

Fig. 3. A scene of the robot conducting the dress assisting caring

Dressing assistance was conducted by Dry-AIREC with the same deep-learning framework. Fig. 3 shows a scene of socks-dressing assistance. The Dry-AIREC can successfully manipulate the deformable socks object and apply the needed force to a foot for dressing without excessive force application.

The Dry-AIREC was able to perform multiple caring tasks. In future work, we plan the further development of a deep-learning model capable of more various nursing care tasks Specifically, we would integrate a semantic recognition model, a large language model, and a deep predictive model for motion generation, with the mobile base, waist, and arm joints.

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