A comparison between proactive and Unremitting robot assistance using collaborative tasks in Nursing care

[1]**Prof. Edna Sweenie J,**
Deputy Director & Professor, Department of Child Health Nursing, Sri Venkateswara College of Nursing, Chittoor – 517127, AP
[2]**Prof.U. Jhansi Rani**,
Professor Department of OBG, Sri Venkateswara College of Nursing, Chittoor – 517127, AP
[3]**B. Madhura Vani**,
Assistant Professor Department of Community Health Nursing, Sri Venkateswara College of Nursing, Chittoor – 517127, AP
[4]**Prof.T. Poornima**,
Professor Department of Medical Surgical Nursing, Sri Venkateswara College of Nursing, Chittoor – 517127, AP
[5]**Prof.E. Sumalatha,**
Professor Department of OBG, Sri Venkateswara College of Nursing, Chittoor – 517127, AP

Abstract - The lack of care for an elderly population is a challenge for our society. Robotics and other cutting-edge technology may help in this situation. Adapting these technologies for use in health care is critical if they are to be widely adopted and utilised in daily life. To help caregivers during the transfer of a patient simulator to the lateral position, a robot manipulator was positioned near a nursing bed and two modalities of contact with the robot were compared and evaluated in this case study. Proactive and continual assistance behaviours are distinguished. As opposed to the continuous technique, the proactive method only begins when it is visually determined that a patient should be pushed into the lateral position utilising a Wizard of Oz experiment setting. Overall, the research found that a robot's constant assistance behaviour was chosen by the participants.

Index Terms—robots, human-robot interaction, manipulators, public healthcare

I. INTRODUCTION

Caregiving will become more difficult as the world's population becomes older and more dependent on others [1]. Since there is a scarcity of nursing personnel, it is essential to develop solutions to alleviate the situation as much as possible. Nursing care is promoting new technologies since they have the capacity to address the issue at hand.

There are, however, a number of issues that need to be addressed with the adoption of modern technology in patient care.

It is necessary for technological engineers to work closely with caretakers in order to accurately represent their demands and the needs of their patients [2]. When it comes to nursing, a lack of technological expertise means that the desire to make things easier and more efficient is even greater.

It is the mission of the Nursing Care Innovation Center to evaluate and create novel nursing care technologies, taking into account the demands of caregivers, in order to improve the quality of life

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for the elderly. At the Clusterkonferenz 2018, an Innovation Center presentation with more than 400 carers got a very good response, suggesting that robots in the nursing industry may be extremely well accepted [3]. For the sake of reassurance, caretakers were also questioned about their requirements and wishes throughout this presentation.

Figure. 1: pro-active support (left), and ongoing support (right) (right).

A high level of acceptability for a human-robot cooperation system is dependent on a number of factors. Questions such as "how" and "when" are particularly important (see Fig. 1). An integrated development and the good feedback from the caregivers for this system [3] took into consideration the issue of how.

It was suggested that a speech-recognition system be installed as soon as possible in order to begin working with the robot. Nevertheless, it is shown in [4] that a human-initiated support system is not the most effective method to accomplish the activity, even if the caregiver prefers to have control over the robot. Proactive assistance was shown to be more beneficial. If you're looking for a certain result, you'll have to choose your setting. Continual assistance is a possible alternative that has to be investigated in the context of nursing care in the case outlined above.

Because of this, the benefits and drawbacks of a proactive and continuous robot-interaction strategy to cooperate during a particular nursing activity are contrasted and explored in this research. During the patient's shift to the lateral position, the caregiver's job is to keep the patient stable so that tasks that need two hands, such as cleaning the bed or caring for wounds, may be completed. The preferred temporal form of robot help is examined in this study. The issue is whether the robot should be proactive, or should it assist on a constant basis? A Wizard of Oz-themed usability research is done to solve this question. Figure 1 depicts the implementation of the two support options that were discussed.

II. RELATED WORK

A Human-Robot Collaboration

HRI (Human-Robot Interaction) situations involving collaboration are becoming more important. Although industrial settings for teamwork in factories now account for the bulk of research, robotic home helpers and space robots are also on the horizon. As the need for assistance in caregiving tasks grows, it is more important than ever to look at HRI apps that are specifically tailored for this situation. In this scenario, direct manipulation of people is a unique feature that has been primarily studied for surgical purposes.

The robot's ability to perceive its surroundings in a safe manner, particularly while operating on its own, is also a major issue. As a result, several safety requirements, such as the ISO/TS 15066 for collaborative robots, were established and published. It is feasible to prevent collisions in the first place if the robot's surroundings is seen visually.

It is possible to safely initiate activity and movement in a research using a Wizard of Oz arrangement. Visual input is provided via a 2D camera video stream.

B *Interaction Fluency*

The importance of time in nursing care necessitates that interaction fluency be improved for a satisfactory user experience. Interaction fluency itself aims to maximize cooperation throughout a shared activity. There are a number of measures that may be used to measure fluency, including the amount of time it takes to complete a given job.

Use of both subjective and objective measurements is the focus of this study. Although the subjective measurements are used to assess how fluent a specific interaction was perceived by the public, objective metrics are used to measure the real idle and active periods of both the robot and human while they were doing a job. When comparing three distinct models for initiating robot activities, subjective metrics such as performance, use characteristics, and subjective preference were employed as a subset of the questions proposed. "Human-initiated," "robot-initiated reactive," and "robot-initiated proactive" were the three strategies examined. There are a few noteworthy changes between, which are cited as inspiration for this paper: Since it was shown to be the least effective, this research does not include methods started by humans. Only proactive and ongoing techniques are investigated for this reason The robot could not fail to fulfil the job as specified, since that is what this research was looking at: help during patient placement. This scenario also involves the robot and caregiver working together on the same job. As a last point, it is crucial to note that such a research has not yet been undertaken in the context of nursing.

III. SYSTEM DESCRIPTION

An environment where a robot and a caregiver may operate side by side in the same time and area was created to test various forms of robotic assistance. Details of this system are outlined in this section.

A *Platform*

Franka Emika Panda is the robot used in this system. This robot has seven degrees of freedom (DOF) of mobility, which allows it to execute a variety of tasks in a wide range of environments. Because of its more than one hundred sensors, the Panda delivers a highly smooth performance while also being very precise and steady. The robot may be stopped with a desired force thanks to the force detection.

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It is possible to halt movement at a chosen moment in this system by using sensors that detect the patient's touch with the device. Fig. 1 shows a contact location between the manipulator and the patient simulator, where an additional cushion was provided.

B *Domain and Task Representation*

Due to a shortage of qualified caretakers, new technology is being introduced to make the job easier and more efficient for those who are already working in the industry.

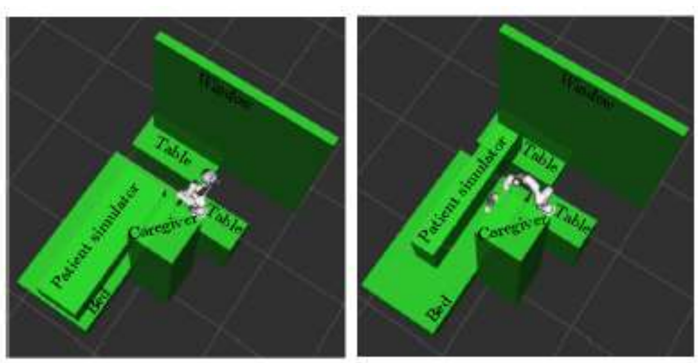
The chore of situating the patient is one of the most promising for both the relaxation of the caregiver and the efficiency of care. Caregivers are needed to move the patient to this position on a regular basis to carry out various tasks, such as inspecting wounds, cleaning the bed, or bandaging the patient. There are times when a second caregiver is needed to aid with chores like the ones cited in this article; however, in most circumstances this person is not accessible. If you don't have access to positioning pillows, another option is to use a sling instead. There are several reasons why, in most situations, carers are unable to complete a job with both hands, since the other is utilized to keep the patient in place, slowing down the process and increasing their workload.

In the case of immobile patients, the use of robots to fulfil the holding role is a potential alternative. Robots need to know when and where they should execute their tasks, and must avoid colliding with both patients and caregivers in order to be widely accepted. The human is in charge of moving the patient, while the robot is in charge of stabilizing him or her.

C *Robot Action Implementation*

There are three pieces to the robot's control system; a camera, a joint position controller using MoveIt, and a Cartesian impedance controller based on Franka Emika Example Controllers.

Fig. 2 shows how collision objects were manually added to the planning scenario without any additional vision detection of the surroundings to prevent collisions with either the surrounding environment or the people near the manipulator. These are able to adjust to the patient's box.



Collision object in start position   Collision object in hold position

Figure. 2: Manually set collision items near the robot manipulator in start (left) and hold (right) positions following patient contact.

It is utilised to plan and execute autonomously to a slightly changed joint state objective at the edge of the bed for continued support. Then, the controller is modified to the \sCartesian impedance controller. The end effector may be moved forward and backward along a predetermined route thanks to this controller. This approach is meant to predict the patient's back position as accurately as possible. While executing, here controlled by hand, this path, the external force on the end effector, computed by the Franka Control Interface, is also monitored. The movement stops and the collision objects are updated in the planning scene if this exceeds the set contact threshold (Fig. 2).

Action selection: In order to avoid the caregiver getting the impression that the robot is taking too long to respond, a scene analysis seems to be a viable solution to this issue. If the robot can identify I the patient's lateral position and (ii) the patient's real position and orientation in relation to the touch surface, it should be able to perform the necessary tasks.

For example, the caretaker may avoid the robot or a consistent gap can be maintained between the robot and the surface. As a result, the robot knows which assistance activities to do. I Based on (ii) the caregiver's activities, a support action's best time may be determined. When using the proactive technique, the work is started as soon as feasible so that the nurse does not have to wait long for robotic assistance. As soon since the nurse enters the room, the assistance begins, as this strategy is flexible enough to adjust to the nursing scenario. When it comes to keeping an accurate distance from its patient, the robot has to be able to constantly modify its trajectory and avoid the nurse at all costs. It is also necessary to recognise the existing condition precisely (ii). The engagement and task execution would be smoother and more pleasant if there was no trigger technique initiated by the caregiver, such as voice recognition.

Proactive technique began by a robot (P): Once the robot recognises that the caregiver has begun turning the patient, the first policy is launched. A contact with a patient causes the robot to stop moving until it is above the patient's bed, at which point it continues to advance towards the patient until it senses a collision and then stops, keeping the patient in place. In this strategy, the robot goes in a straight path until a collision is detected, rather than following the patient's indicated course.

IV. USER STUDY

This research investigates how a nurse and a robot may work together in a meaningful manner when they do a nursing activity (moving from supine to lateral position) at the bedside via the use of a robot's interaction approach. For nursing personnel, robotic support devices will play a significant role over the next several decades. Nursing personnel, on the other hand, must be comfortable with the robots' working ideas before they can collaborate effectively. This study compared two operational concepts in order to find the best one. A patient simulator was used in this study. Furthermore, the research was conducted as a Wizard of Oz study, in which a human was remotely controlling the robot's inability to do certain activities.

The experiments outlined in III-C are being tested.

A *Study Design*

A within-subjects study was conducted to see whether carers were happy with the robot's working mode. The robot's behaviour was the independent variable in this research, and the two conditions were P and C. (Sec. III-C).

Nursing personnel had to do the identical action in all three scenarios: turn the patient simulator to the side and wait for the robot to come and hold it in place so that the carers could release it.

We didn't care which strategy was used first, thus a random sequence was chosen and displayed to the carers.

A Wizard of Oz research was used since the study's primary goal was to determine whether or not the two techniques offered by the authors were relevant and wanted by the nursing staff. Some functions of this scene analysis were remotely controlled and carried out by a person in order to replicate it. In the proactive technique, the human hits a button in the teleoperation centre, which begins the movement of the robot to the starting location, and once it reaches its target, the robot commences the movement until collision with the patient is detected. When employing the continuous technique, a button is pressed to activate the robot's movement to the beginning position, and the person in the teleoperation centre uses a joystick to direct the robot's movement as it interpolates the new needed position based on the speed and force of the joystick.

B *Setup*

A teleoperation centre and a live lab were used for the investigation because of the Wizard of Oz arrangement. The teleoperation centre is used to operate the simulated system components for the Wizard of Oz research.

Activation of the actions and the anticipation of the patient's rotation with the manipulator end effector in continuous case are two examples of these It's from here that we pick our circumstances and measure our times, as well.

Bedroom: In the bedroom, as depicted in Fig. 3, there is a bed on which the patient simulator is placed, a robot arm situated 25 centimetres above the bed, a monitor showing the caregivers which method is being used and when they can begin as well as when the process is complete, a camera showing data to the operator in the teleoperation centre and, finally, two marks in the floor indicating when the process is complete..

The first mark shows where the caregiver should wait for the monitor to indicate that the procedure is ready to begin (screen turning green). The second identifies the place in the process flow from which the operation must be performed. For optimal cooperation, it is situated at a distance of 2.20 metres from the beginning position mark and 60 cm from the robot.

On pressing either "proactive" or "continuous," a clock was started and displayed in the GUI to keep track of how long the study took in the teleoperation centre. A red screen appeared in the caregiver's bedroom to indicate which method was going to be tested, but after fifteen seconds this screen turned green, indicating that the caregiver's method had been evaluated. The proactive and continuous methods were engaged by clicking on the "stabilise" and "continuous route" buttons.

The joystick used to operate the robot in the continuous method was a Novint Falcon 3D Touch Haptic Controller. The aim of utilising the joystick was to decide the new location the robot had to go to. When the speed and force of the controller were applied, an interpolation between the several specified places was created.

Lastly, using the information supplied by the camera in the bedroom, the operator in the teleoperation centre was able to detect the caregiver as well as the robot and initiate each necessary step.

Procedure: For the investigation, the two circumstances specified in III-C were used, each of which lasted no more than 10 minutes.

Immediately after each condition, a 5-minute questionnaire should be completed. The experiment lasted little more than 30 minutes in all.

Patient simulator in a bed was the focus of the caretaker's efforts. Robot manipulator next to bed helped in this duty by maintaining patient in secure posture by supporting by holding them.

To begin, the carers received a brief introduction outlining the purpose of the research (to identify which strategy was best for the caregiver). The steps to be taken were also outlined and shown for the audience's benefit. Detailed instructions were provided to participants, including the fact that this was a Wizard-of-Oz research.

The caretakers positioned themselves at the specified start position and following the start signal, after the screen of the monitor went green, they moved the patient simulator from the supine to the lateral position on the bed. The patient simulator was then stabilised by the robot. After that, they were asked to fill out a survey to rate their experience. The same method was repeated twice. " Changes were made to the robot's support services. Prior to the experiment, the individual was shown a red screen with the method's name on it on the monitor. The execution time was recorded for each run. To wrap things off, the caregivers were invited to fill out a demographics survey and rate the support ideas they were most familiar with.

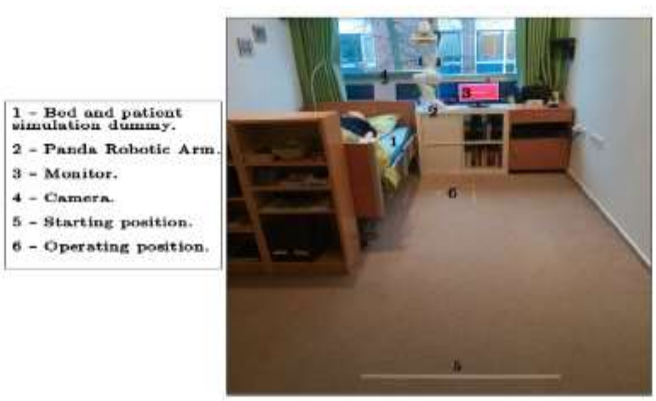


Figure. 3: Setup of the bedroom.

Measurements: As a way to compare both circumstances, objective and subjective measures were collected. Specifically time and questionnaires were used.

1) *Time:* In all scenarios, both the robot and the caretaker's idle periods were recorded, as well as the total time needed to complete the operation. The start signal set the timer in motion. When the condition (contact of the manipulator with the patient) ended, the total execution period was immediately halted. The amount of time spent in idle mode was recorded manually.

2) *Questionnaires:* With this research, a preset questionnaire was developed from [4] for the purpose of collecting the nursing staff's opinion and comments.

No personal information other than age and gender is collected by the questionnaire, which includes the same question in both scenarios. However, all information is kept confidential.

How helpful the robot was in the work, the efficiency and fluency of cooperation, how natural the interaction seemed, whether the task division was equal, and any remarks the participants wished to give were some of the questions that were asked. A further question was posed concerning the impression of robot aid, and the individuals were asked to choose which situation they preferred.

V. RESULTS

Seven caregivers participated in the research, two of whom were men and five of whom were women. They were between the ages of 32 and 60. (mean: 50.3, standard deviation: 9.6).

A two-sided paired T-test was used to compare the two circumstances.

A *Objective metrics*

Multiple time stamps were collected and analysed after the research concluded in order to compare the two approaches.

The impact of the circumstances on the total execution time is first investigated. Total execution time may be shown in Figure 4, based on the given circumstance. There is a significant reduction in total execution time, t(6) = 4:46, and p =:004. Figure 5 (a), t(6) = 11:38, p :001, shows that under the continuous situation, human idle periods are much reduced. Figure 7 depicts the robot's idle moments (b).

B *Subjective metrics*

Participants were asked to respond to seven-point Likert scales using a number between 1 (strongly disagree) and 7 (strongly agree), as detailed in IV-D2 (strongly agree). Participants were given the option of leaving comments in a blank space, and demographic information was also included.

The findings of the questions on the quality of engagement. Using a one-sided pair-TTest, the mean values of the replies were calculated and compared to each other. There was a significant difference in the quality of the interaction between the two methods (t(6) = 2:39, p = 0.027).

A two-sided paired T-Test is used to examine correlations between subjective judgments and objective measures. According to Fig. 5, there is no correlation between subjective assessments and the robot-idle time. The connection between subjective assessments and total execution times is negative, t(6) = 2:88, p =:014.

t(6) = 0:93, p =:394. There is no link between age and the quality of interaction rating.

The caregivers choose which strategy they preferred after a series of questions and answers. Of the seven caregivers, five (71 percent) picked proactive, one was unconcerned about either option, and the last caregiver was agnostic.

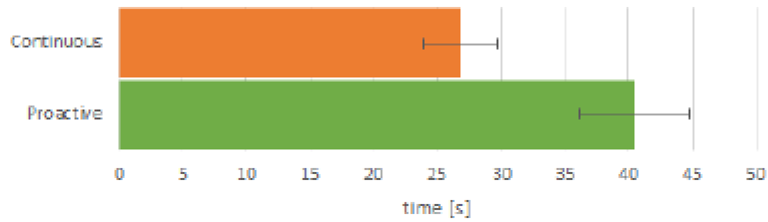


Figure. 4: Finish time for each condition. Error bars denote SD

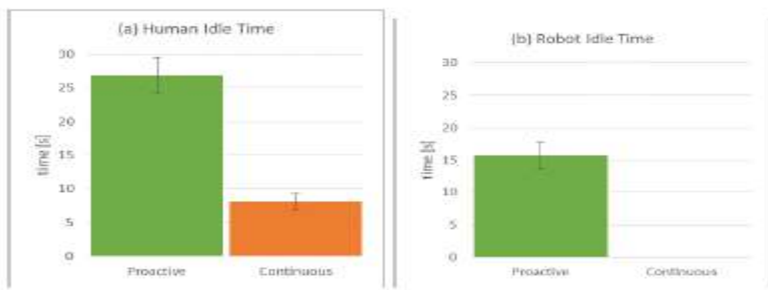


Figure. 5: Idle moments for humans and robots. Error bars denote SD

For each situation, an open-ended question was posed regarding how people felt about robots helping them Table I shows the qualitative assessment of this question, where amount refers to the number of times the item is stated. A "helpful" robot was described as "too sluggish" and "too passive" by those who encountered it. The following is how the proactive action of the supposed robot was described in the German translation:

M, 52: "The robot's motion is excessively slow."

M, at the age of 59, says, "You're not active enough."

If W, 50, had to work alone, "[...] it would be a tremendous benefit."

The continuous support robot was described as "useful" but also as "uncertain to collaborate with." In its German version, the ongoing behaviour of the seen robot was described as follows:

W, 45 "It's a little strange at first."

"Fluently, time-saving." — M, 52

TABLE I: Question: "How did you perceive the help behaviour?"

Category	Quantity	
	Proactive	*Continuous*
Cooperative	0	1
Helpful	2	5
Safe	1	0
Too inactive	2	0
Too slow	6	0
Uncertainty in the cooperation	1	3
Unhelpful	0	1
Other	1	1

VI. DISCUSSION

The data supports the premise that caregivers prefer the continuous strategy over the proactive one. From both objective and subjective measurements, it is possible to draw this conclusion. Chapter V-A demonstrates how much quicker the continuous technique is in completing the work. In addition, the nursing staff will have to wait significantly less time for the robot to arrive. This means that the caregiver will be able to do any other work in a shorter period of time since they will be able to free up their hands sooner. In chapter V-B, the quality of interaction is demonstrated by the subjective assessments. Qualitative findings suggest that a nurse and robot working together continuously increases their level of apprehension about using this new technology. Typical assistance in this activity do not facilitate the process of "mobilizing to the lateral position," which may account for this.

As indicated in V-B, the majority of participants preferred the continuous technique when asked whether the robot should help once or continually. Despite the fact that caretakers liked the continuous strategy over the proactive one, they also noted that it had to be improved since it first seemed a little unnerving to them. When they arrived to the bed for the research, several of them were surprised to find that the robot was already moving.

During support activities in human-robot cooperation, robots are shown to predict the best feasible support position at all times, according to the research, and are therefore rapidly ready to assist. As a result, further study is needed in this area as well.

VII. CONCLUSION

It was the goal of this article to determine whether strategy, proactive or continuous, was preferable for aiding the caregiver in getting the patient to the lateral position. The proactive method relies on the robot to help only after they had brought the patient to the lateral position.

Results suggest that the continuous technique is preferable to other methods, despite the need for future enhancements to decrease uncertainty during cooperation. In the end, this might lead to a more efficient and effective technique for reducing the burden and stress of nursing care. These findings might be tested in other domains, such as manufacturing, in the future.

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