Functions of A Caring Robot in Nursing

Shihong Huang[1], Tetsuya Tanioka[2], Rozzano Locsin[3], Marilyn Parker[3], Oren Masory[4]

1) Dept. of Computer & Electrical Engineering and Computer Science, Florida Atlantic University, U.S.A, Email: shihong@fau.edu
2) The Graduate School of Health Biosciences, Department of Nursing, The Tokushima University, Japan
3) Christine E. Lynn College of Nursing, Florida Atlantic University, USA
4) Dept. of Ocean and Mechanical Engineering, Florida Atlantic University

Abstract— **There are many different types of robots that are used in different fields to make our lives easier. Currently, a popular assistive robot used in health care includes the "support robot" that helps persons' mobility and the "rehabilitation robot" that facilitates the performance of range-of-motion exercises. A robot performs tasks with mechanical precision on its own, or with guidance. Many fundamental questions exist that challenges the development of assistive health care robots, such as (1) What is a caring robot? (2) Should caring robots be humanoids or not? (3) What necessary functions are required for these caring robots so that it can provide quality nursing care? (4) What level of intelligence should robots have so that it can function effectively as a responsive 'assistant' to patients? (5) What levels of decision-making should the robot have to be a dependable partner solving patients' care problems? Based on nursing caring theories, the authors of this paper propose a set of necessary functions that a caring robot should have, so that these questions can be answered. A caring robot has functional features like that of a human nurse. Developing humanoid robots will enhance the necessary functions of a caring robot particularly in task for example, taking vital signs and delivery of meals and medications. The most important ability of the caring robot is to carry-out basic nursing care functions as expected by the patients. This paper aims to apply nursing caring theory as a framework for the patient human-robot interaction.**

Keywords: robot, nursing care, knowledge management, natural language processing, nursing theories, indexing

I. INTRODUCTION

According to the Ministry of Internal Affairs and Communications [1], the population of the elderly in Japan was 2.90 million in 2009, accounting for 22.7% of the total population. Also in Japan, it is expected that the population of elderly people will continue to grow rapidly, consequently increasing the need for quality nursing care for the elderly. Moreover, the work environment especially in elderly care has changed considerably, expanding not only to hospitals but also to various health care facilities such as in nursing homes. This affirms the burgeoning needs for more efficient and quality performance of nursing care [2].

However, there is a shortage of nurses [3] and other nursing care personnel [4] in Japan today. This situation has hindered efforts to provide a better healthcare for people. This shortage of nurses in part is due to the rapidly declining birthrate and longevity. Securing a stable source of manpower is an important consideration among the Japanese population. Subsequently, the development of caring robots that provide nursing care instead of human beings has attracted much attention as the quintessential solution to manpower concerns. When using caring robots in nursing care settings, the most important factor is to understand the functional roles of these robots. For example, one needs to appreciate not only the required aid in daily activities, but also the care corresponding to the degree of self-care, and the care focusing on therapeutic communication like in cases of mental health and psychiatric care.

Currently, the popular care robots such as "support robot" helps people move [5] and "rehabilitation robot" that provides passive range-of-motion exercise [6] have been in use in health care institutions. However, some of the fundamental questions regarding the application of robots in health care still have to be answered:

- What functions are robots required to perform in order to provide quality nursing care?
- Should these caring robots be humanoids?
- At what level of intelligence should robots be in order to function effectively as responsive to patients' health care needs?
- At what level of decision-making should the robot be in order to become a dependable participant in solving health care problems?

Therefore, the authors propose that research efforts devoted to the following topics will help define the roles of robots in health care and indirectly may provide relief to the increasing problem of the nurse staffing shortage: (1) Identifying the needs for a caring robot to recognize nursing care real life situations; (2) Creating humanoid robots which can perform some selected, desired basic nursing functions; and (3) Introducing caring robots to identify nursing care situations in order to validate the best practice approach with the best predictable health care outcomes. In addition, because caring robots will play the role like a real nurse, the most important function, if the caring robot is developed, is for the robot to be able to recognize and carry out basic nurse functions as close to how caring human nurses do. To facilitate the understanding of the purpose of the caring robot in nursing care situations, this paper will use the theoretical framework of caring in nursing,

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specifically Locsin's [7] mid-range theory of Technological Competency as Caring in Nursing. This theory aims to frame a theory-based nursing practice in which the functionalities of care are grounded in a process that is supported by legitimized assumptions of practice.

II. CLASSIFICATION OF NECESSARY FUNCTIONS TO DEVELOP THE CARING ROBOT

A robot is typically understood as a mechanical device that exhibits motion and capable of manipulating tools. It accomplishes automated and complicated tasks by means of programming, interfacing to sensors and to some degree artificial intelligence (AI). In addition to the above characteristics, caring robot requires to exhibit mobility in order to perform a simple task such as fetching a cup of water. Next, it should possess self-learning capability necessary to behave like a human nurse. It is important to recognize that a robot can do only what a robot is programmed to do. That is why we often hear the comment “Oh! Don’t be like a robot!”.

Nursing is an integral part of patient care, and as such, a nurse gives intimate nursing care to a patient, considering the physical, emotional, social, economic, and spiritual needs of the patient. A caring robot should provide similar functions, in particular it should to be able to apply the basic nursing care defined in “Caring Theory” as described in Locsin’s “Knowing Persons: A Framework for Nursing” [7]. Work has been done in using computer-aided techniques to automatically classify the knowledge that nurses can have as a product of their interaction with patients. [9]. The interactions between nurses and patients are captured as narrative stories and expressed in nursing languages. Nursing language and all expressions of nursing are essential attributes of nursing as a discipline and profession [10].

A. *Classification of conversational robots*

One of the most critical functions of a caring robot is its ability to communicate effectively and with proficiency. Based on the different levels of robot complexities, these conversational capabilities can be classified into three different levels as identified and described in Figure 1.

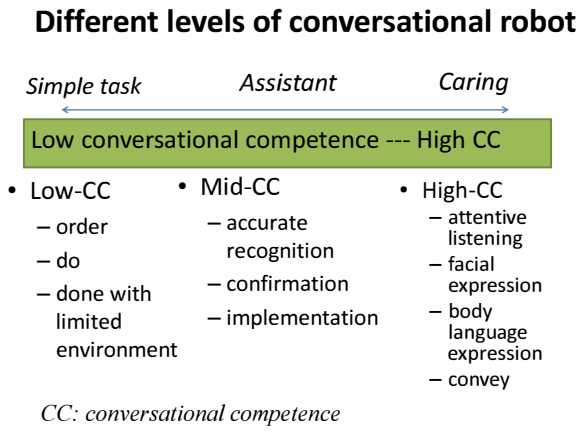

Figure 1. Classification of conversational levels

A low conversational competence of a robot relates to the performance of tasks in a limited environment (e.g. ward and outpatient area). In this case, the robot would have some basic conversational abilities with the patient, as well as recording capabilities for conversations to be further analyzed. It is expected that caring robot functionalities are limited to tasks that the robot can perform within a limited nursing care environment. The features of these functions are also limited to a uni-directional or mono-directed order, such as "give me water." This task involves (*order* by the nurse and *doing* by the robot) motion within a limited environment such as the patient's bedside.

For a mid-conversational competence robot, the order given by the nurse or patient should be accurately interpreted (AI capabilities expected), analyzed and confirmed, and performed (implementation). A coordinated action between the patient and the nurse is needed to define the robot activity in assisting the nurse and the patient. The robot would have higher intelligence that can respond to some nurses' or patients’ questions. For instance, when the nurse commands the robot to transfer a patient from a bed to a wheelchair, a precise conversational ability of the robot is necessary to establish an intelligible robot-nurse dialogue. Such an activity is predicated on a perspective and a confirmation of the nurse's instruction, focused on a “conversation competency”, and efficient “motion competency”.

- A high conversation competency, between a robot and nurse, is needed for the following functions: Attentive listening (accurate recognition of the other person's vocal inflections and corresponding head movements conveying the most accurate feelings)
- Emotional expression that corresponds to the facial expression, e.g. vocalization is appropriate to the facial and head movements
- Body language exhibited is corresponding to the head expressions, vocalization, and facial expressions - emoting the corresponding feeling
- Robot is able to express all these and confirmed by the nurse through the continuing dialogue that convey the person-robot interaction

Based on these functions two different categories are represented: the robot’s conversation competency (CC) – the “conversation robot”; and the robot motion competency (MC) – the “action robot”. The ultimate achievement factor would be a robot possessing both high CC and high MC. The robot is both conversational and with a high mobility function.

B. *Kinds of Robots*

In this paper, six distinctive types of robots are described. Table 1 presents the different classes of robots and their respective descriptions. These kinds of robots are some of the more popular ones that are currently in use.

Table 1: Robots' classification

Different kind of robots

1. Industrial robot (to reduce costs, improve productivity and to help people with dangerous work) ,
2. Military robot (remote-controlled devices designed for military applications)
3. Weather-monitoring robot (continuous weather monitoring including temperature, wind, pressure, and humidity)
4. Service robot (e.g. at Germany's fully automated "robot" restaurant)
5. Medical robots (e.g. to assisting doctors during surgery)
6. Robots for nursing care and living assistance (able to communicate with humans via voice and gestures)

These robots do not have yet the required characteristics in order to be function successful as a caring robot. A caring robot can function effectively only when its functionalities are appropriately based on a formalized model of nursing [7].

The development of the caring robot for health care is the focus of this paper. The terms "Nursing robot", "Care robot" and "Caring robot" are often used interchangeably and described the same thing. However, there is a need to consider each definition and the kind of activity (role) nursing robots and other types of robots perform in the limited environment such as a hospital or a wardroom. As a functional ability required for a nursing robot, it has to have mobility, manipulation, and conversational abilities that are at a level of intelligence that will allow for assessment of the patients' conditions.

By conversational ability, the communication through dialogue between a robot and a human being is meant to be specially intimate. Furthermore, in order for a robot to function as a nursing robot, it must be able to deliver a sound judgment based on the value and significance of the information received assuring cooperation with a patient, a nurse, and a doctor. A robot function must include its ability to judge and to move within specified boundaries. For example, if it is a guidance robot in the lobby of a hospital, low conversation capability and movement are enough functions. However, for a nursing robot judgment competency required. For a nursing action it is critical that the robot possess a framework of practice that is the basis for its functionalities (actions). The authors propose a framework of nursing that is based on Locsin's theory of Technological Competency as Caring in nursing [7]. Within these demands for nursing activities, the model provides a prescriptive direction from which a nursing robot action can be based (see Figure 2).

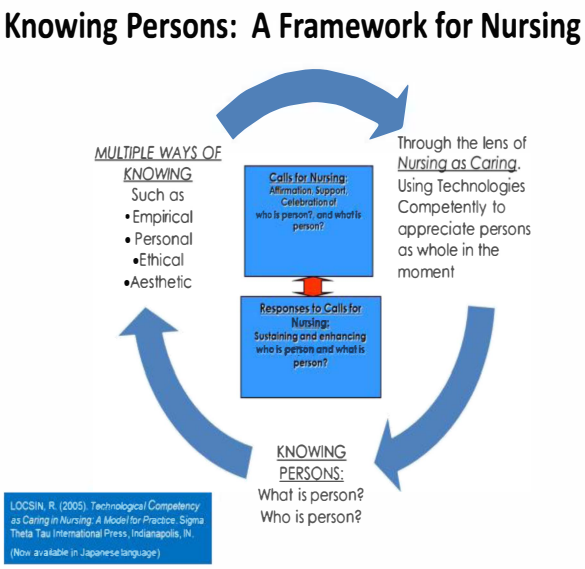

Figure 2. A framework for nursing

III. NURSING CARE AND TECHNOLOGY: THE IDEAL CARING ROBOT

Nurses use and encounter technology in nearly every aspect of their professional practice. What does it mean to be technologically competent and caring as a nurse? How does technology support nursing work? How does it hinder nursing work? How can nurses care for their patients as technological advancements are introduced nearly every day? Technological Competency as Caring in Nursing: A Model for Practice [7] provides insights and answers into how nurses can and must be technologically competent to express being caring persons and provide meaningful and essential nursing care.

A. Knowing persons and caring robots

A conversational caring robot should be able to ask and answer intelligent questions to patient based on a nursing caring framework. Grounded on a patient's story and other data such as vital signs, the conversational robot should ask more in depth questions in order to get a more accurate picture of the patient's situation. The use of Carper's Fundamental Patterns of Knowing in Nursing is advocated here [8]. These ways of knowing are:

- Empirical or scientific way of knowing
- Personal knowing
- Ethical knowing
- Aesthetic knowing

These fundamental patterns occur simultaneously as expected in a formalized process of nursing. These patterns of knowing are used in the process of knowing persons - the framework of nursing [7].

Empirical knowing is expressed as scientific competence - competent action grounded in scientific theories and nursing science. Caring robots can obtain data such as patient's vital

signs: pulse rates; blood pressure; body temperature; facial expression, and voice tone, etc. Likewise, caring robots can ask patient “How do you feel now?” “Do you have a headache?". Thus, a comprehensive assessment can be made from the collected patient's data including the responses of patients during the robot-patient conversation. Moreover, all the obtained data is transmittable to nurses and physicians in various media formats.

Ethical knowing involves making moment-to-moment judgments about what ought to be done, what is good, what is right, and what is responsible. Ethical knowing guides and directs conduct in life and work helps one determine what is most important, where to place one's loyalty and what priorities demand and advocacy.

A database for collected data from ethical situations is important. These will guide the caring robot to act in moral situations. Minimum competency of caring robot is not to harm human beings

Personal knowing concerns the inner experience of becoming a holistic, authentic self - capable of unifying the plural dimensions in which that self lives in an honest and open manner. Full awareness of the self, and the context of interaction with others make these possibilities meaningful shared human experiences.

In creating the caring robot, it is important that the technology of Natural Language Processing and Facial Expression recognition are major composites. In particular, its most important competency is the ability to engage in some aspects of conversation and movement that reflects the interpersonal relations between the patient and caring robot, with caring robot conveying some semblance of emotional expressions.

One way to enhance the ideals of a caring robot is by aesthetic knowing. Aesthetic knowing involves a deep appreciation of the meaning of a situation and calls forth inner creative resources that transform experience into what is not yet real, bringing to reality something that would not otherwise be possible. In order to create this ideal feature from caring robots, like a human nurse, robots must have some enhanced form of artificial intelligence that can provide some possibilities to create emotional behavior.

Congruent with the works of Locsin and Carper, the distinct language of a discipline and practice include words and expressions as well as knowledge of needs and responses appropriate in a given situation. Research data on nursing language, including both verbal and non-verbal expressions of caring have been generated and categorized for use in developing the caring robot [10].

B. Caring robots and the five senses

If a caring robot were like a human nurse, it must have the capacity to express the five senses, and a programmed computer that gathers, unifies and analyses the inputted data indicating that it is able to understand and express an appropriate response as indicated in Figure 3.

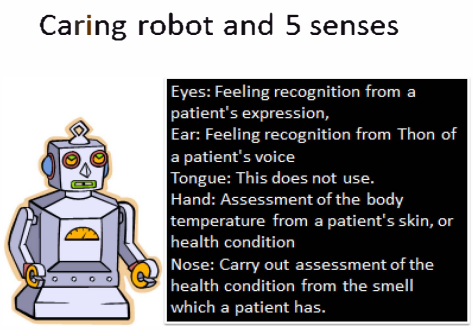

Figure 3. The five senses of a caring robot

Furthermore, caring robots must have the capacity for 1) accurate recognition of nurse's instruction, 2) confirmation of nurse's instruction, 3) mid- to high-level “conversation competency”, and 4) “motion competency”.

In order for a caring robot to convey a compassionate response to a patient, the robot must perform activities with a polite voice, and must be able to use culturally adapted and compassionate body language. The robot must be able to convey empathy to a patient as indicated in Figure 4.

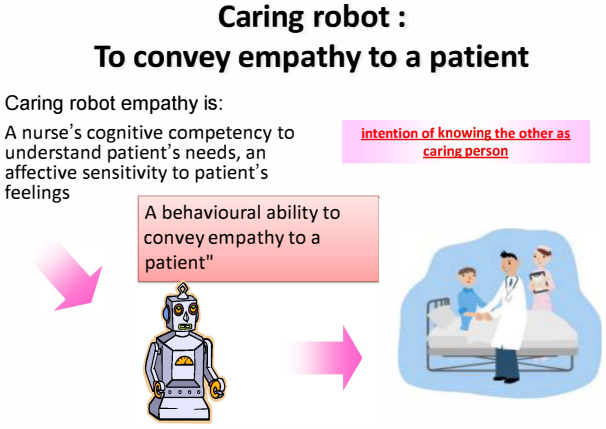

Figure 4. Robot’s ability to convey empathy

Caring robot must be able to perform and automatically adjust its speech to be based on different audience characters, e.g. a child, or an elderly. With these characteristics, a database, which accumulates the cultural feature in communication, is required.

IV. SUMMARY AND FUTURE WORK

This paper proposed the classification of necessary functions of caring robots applying a nursing caring theory into a caring robot’s daily duties, and classifying these necessary functions based on different caring needs. The paper discussed the requirements of different levels of conversational robots based on its complexities, the creation of a robot that knows nursing care and could utilize a good combination of nursing and technology. Finally, the paper points out that the

development of a caring robot needs to consider the human being's five senses of interaction with outside environment.

Any technologies and its intelligent use can only be widely adopted by the nursing care community if it is developed within a patient's viewpoint of care. The future work will include a detailed empirical study of available technologies and robot applications in service domains involving patients and nurses, and to collect first-hand data and observation as to which functionalities are really needed in creating a caring robot.

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